Dr. Dobb's Journal of

#116 JUNE 1986
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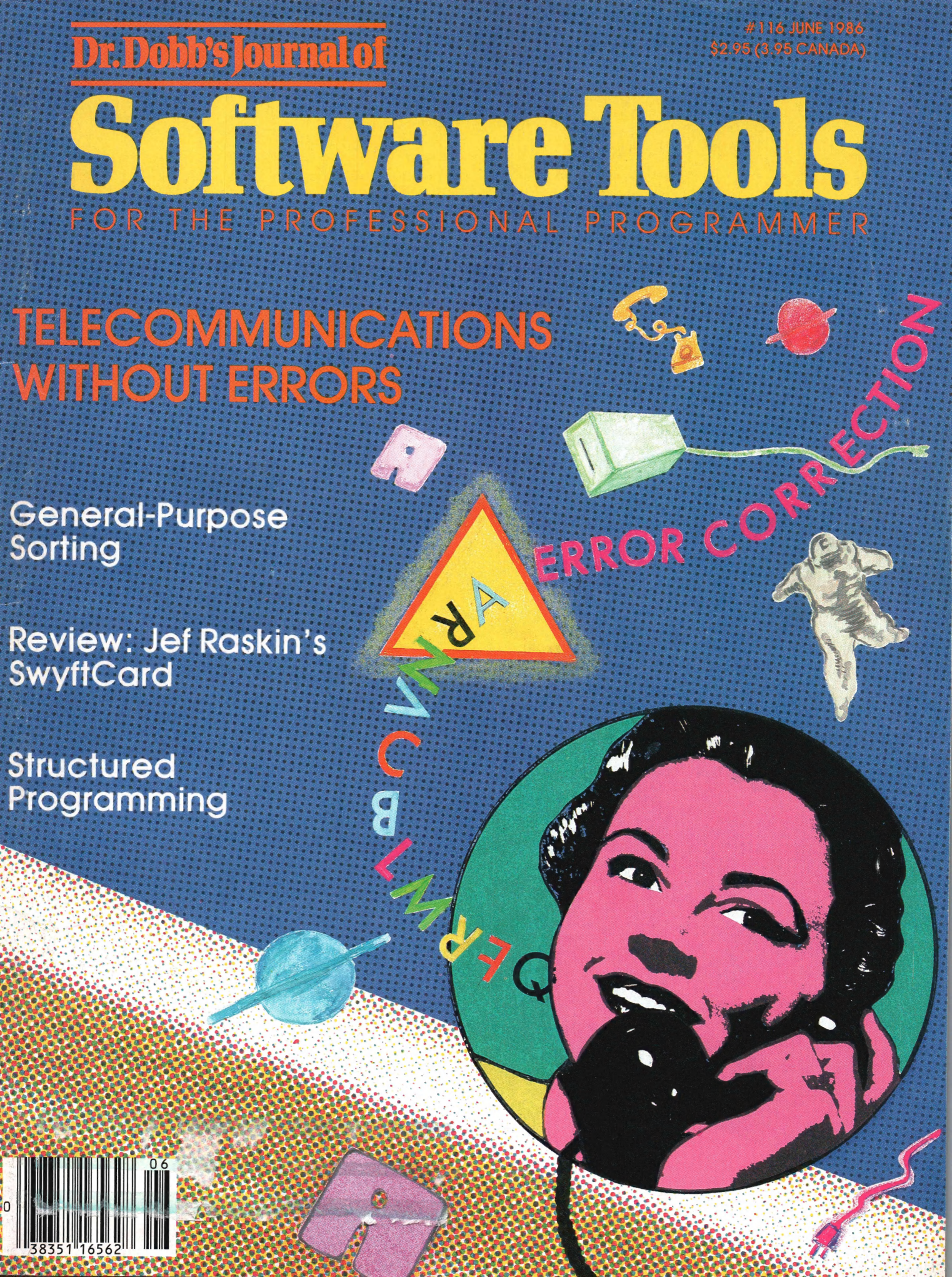

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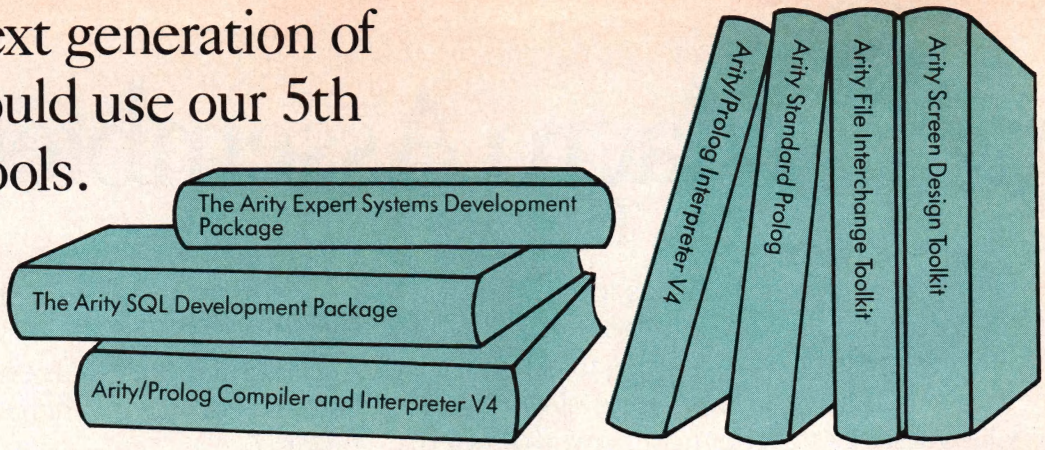

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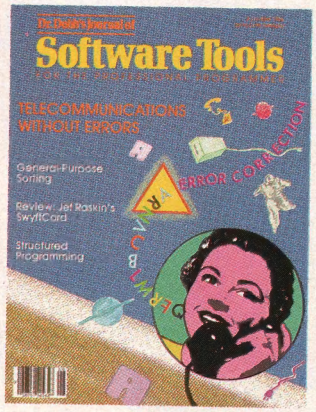

About the Cover
Claudia Steenberg-Majewski pulled this collage out of the blue.

This Issue
This month, we present some relatively painless ways of ensuring error-free telecommunications transmissions. We review Jef Raskin's SwyftCard, a new environment for the Apple IIe and IIc. Especially noteworthy about SwyftCard is that its user interface is philosophically different from that of the Macintosh. Namir Shammas kicks off our Structured Programming column with an invitation to the readers. Michael Swaine, having decided that the back page is his to burn from now on, illuminates his intentions and lights a candle for some of those who have inspired him.

Next Issue
In July, we celebrate Forth. There will be a proposal for a new standard for extended control structures, and we'll shed some light on how to use windows in Forth. Also, in casting about for a novel application, we came up with an implementation in which Forth plumbs the ocean depths. Michael Ham will cover Forth in the July Structured Programming, and even Ray Duncan will get in on the party. For a change of pace, we'll review a number of "turbo" boards for the IBM PC.

YOUR COMPUTER LANGUAGE IS QUIETLY BREEDING REAL BATS IN YOUR BELFRY.

WE'RE OUT TO SAVE ONE MILLION FRUSTRATED PROGRAMMERS

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1) write around the problem by creating six pages of emetic code...

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3) get yourself a world class headache (or a stroke) by dropping into assembler.

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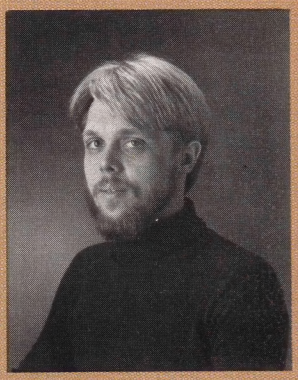
EDITORIAL



Do you know the meaning of "MORF"? Does ":-)" mean anything to you? These are just two of the ASCII shorthand notations sent over the public on-line networks by modem users. A whole new culture seems to be developing in which people who never hear each other's voices meet, get to know each other, and trade even the most intimate of secrets. Anonymity is the rule. You need reveal your true identity only if you want to. The new teleculture is just one facet of the rapidly growing consumer telecommunications industry.

Recent estimates by various sources put the amount of data traffic on the nation's phone networks at 30 percent of total usage. In downtown Manhattan, data traffic is thought to be around 50 percent. Within a few years, those percentages will rise dramatically. Most of the new use is business related, but the consumer market is also expanding rapidly. Recently, CompuServe announced that it now has more than 250,000 subscribers and is gaining between 4,000 and 7,000 new users every month. The Source is adding useful new features (such as special interest groups) and attracting lots of new subscribers. Delphi, People/Link, the WELL (Whole Earth 'Lectronic Link), Dow Jones, and many others are also growing rapidly.

New, exotic features seem to be among the main selling points for the big on-line services. Many boast that they can provide more on-line databases or this encyclopedia or that travel reservation service. Everything from weather forecasting to astrological predictions seems to be available. You can even buy cars, boats, and houses on line.

I can't help but wonder what percentage of the services offered are actually used. What part of the revenues of the big systems actually comes from their "useful" services? I suspect that most of the on-line time is spent in interactive "chat" mode, in which two or more users send lines of text back and forth in real time. I think the next largest amount of time is spent reading messages in SIGs and forums. This is not necessarily a bad sign—in fact, I think it's a sign of the new culture emerging. But the novice may not be getting a very accurate picture of what to expect from some of the current advertisements. People are being led to join on-line services by grand visions that don't necessarily reflect the reality. Why do only a few of the on-line services advertise (and even celebrate) the features that people actually use most?

By the way, "MORF" means "male or female?" and is used as an initial greeting by many chat mode afficionados. The symbol ":-)" is a happy face turned on its side and is appended to a sentence to indicate good feelings or humorous intent, as in "You're such a nerd! :-)" Sometimes the symbol ";-)" is used to show that the sender is winking. Can you guess what "=-0" means?

DDJ is always interested in your article ideas. Right now we're particularly interested in articles for September (algorithms) and October (80286 and 80386). Give me a call at (415) 366-3600 if you've got a nifty idea, or send me a proposal (with an outline, please) at the address in the masthead.

Nick Turner

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Manx Aztec C86

"A compiler that has many strengths ... quite valuable for serious work"

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improvement.

	Execution Time	Code Size	Compile/ Link Time
Dhrystone Benchmark			
Manx Aztec C86 3.3	34 secs	5,760	93 secs
Microsoft C 3.0	34 secs	7,146	119 secs
Optimized C86 2.20J	53 secs	11,009	172 secs
Mark Williams 2.0	56 secs	12,980	113 secs
Lattice 2.14	89 secs	20,404	117 secs

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler	Symbolic Debugger
AS86 Macro Assembler	LN86 Overlay Linker
80186/80286 Support	Librarian
8087/80287 Sensing Lib	Profiler
Extensive UNIX Library	DOS, Screen, & Graphics Lib
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Z (vi) Source Editor -c	CP/M-86 Library -c
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MAKE, DIFF, and GREP -c	Source Debugger -c
One year of updates -c	CP/M-86 Library -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

Aztec C86-c Commercial System $499
Aztec C86-d Developer's System $299
Aztec C86-p Personal System $199
Aztec C86-a Apprentice System $49

All systems are upgradable by paying the difference in price plus $10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

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PRE-C $395 — **Windows for C $195**
WindScreen $149 — **FirsTime $295**
SunScreen $99 — **C Util Lib $185**
PANEL $295 — **Plink-86 $395**

MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

Manx Aztec C68k

"Library handling is very flexible ... documentation is excellent ... the shell a pleasure to work in ... blows away the competition for pure compile speed ... an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

Optimized C	Creates Clickable Applications
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Overlay Linker	Easy Access to Mac Toolbox
Resource Compiler	UNIX Library Functions
Debuggers	Terminal Emulator (Source)
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LETTERS

Ada

Dear *DDJ*,

As you may be aware, SuperSoft has always been a supporter of *DDJ*. I was particularly interested in the February 1986 issue, which included an article that concerned our Ada compiler. (See "Learning Ada on a Micro.") I was sorry to see, however, that there was no information on how to purchase our Ada in the article. We would like to offer the readers of *DDJ* a 30 percent discount if they mention the magazine when they order Ada by calling (800) 762-6629.

Margie Foote
SuperSoft
P.O. Box 1628
Champaign, IL 61820

STAGE2

Dear *DDJ*,

Years ago, in the late 70s, I used a version of STAGE2, a remarkable macro-converter program, on a DEC PDP-8/E.

More recently, I could see in the CPMUG Library a STAGE2 for the 8080 by Dick Curtiss.

Do you know of the availability of such a macro-converter written for PC-DOS?

Guy Dewarichet
Ave. George Bergmann, 33
B - 1050 Brussels
Belgium

8080 Simulator

Dear *DDJ*,

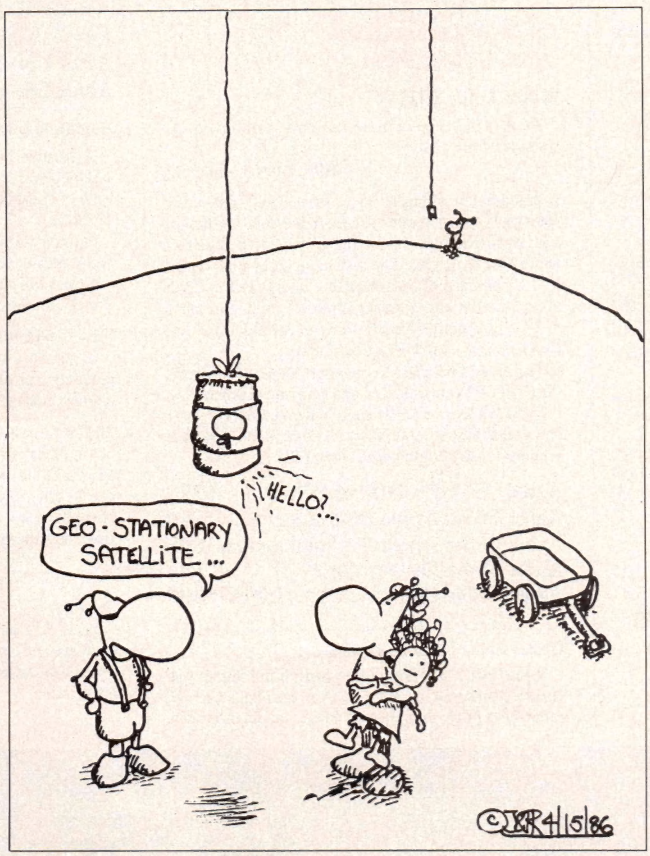
While I was looking through my article "COM: An 8080 Simulator for the MC68000" in *DDJ* (January 1986), I noticed that I had some pretty bad code in the logical instructions. COM originally had all the 8080 registers in memory; with Version 1.2 I moved all the accumulator and flags into 68000 data registers. Unfortunately I didn't take advantage of all the 68000 instructions that I now could. The sequences in Table 1, page 10 (from Version 1.1) could now be written as appears in Table 2, page 10, instead of the way they were published—provided that the high byte of *d0.w* is always assured to be zero. (This is the case with the published code.)

Similar improvements can be made to all *xra*, *ora*, *ana*, *sui*, *ani*, *xri*, and *sub* instructions. *Add* and *adc* instructions don't get shorter because of the *daa* logic, and *sbb* doesn't because of *subx.b* restrictions. The XOR simulations aren't as short as the others are because the 68000 requires the source operand of *eor.b* to be a data register. Along with some short improvements to my *ral*, *rar*, and *daa* instructions (suggested by Edmund Ramm of Germany), changing *dad h* to a shift instruction, and removing an extraneous instruction from *jmp*, I ended up with no perceptable difference! As I had figured before, the real bottlenecks in this program are the opcode dispatcher and the *call*, *jmp*, and *ret* simulations.

The only way I see to really speed this up is with a 68020. As well as having a speed four times faster on 68000 programs, the 68020 has an additional addressing mode of memory indirection that should speed up the opcode dispatcher, and it allows word accesses to odd byte addresses. Table 3, page 10, shows what *call* would be trimmed to.

Perhaps someone with a 68020 machine would care to implement this program and report back the results.

Jim Cathey
ISC Systems Corp.
TAF-C8
Spokane, WA 99220



Inefficient C

Dear *DDJ*,

I'd like to comment on Hal Hardenbergh's Viewpoint column entitled "Inefficient C" in the January 1986 issue of *DDJ*. Although I agree, for the most part, that C isn't as efficient as assembly language, I feel that he overlooked some very important facts:

1. There are many C compilers on the market, particularly for the 8086/8088 processor. The quality of the code produced by these compilers ranges from decent (Manx Aztec C86) to rotten (Lattice C). The size and speed of the code produced by these compilers varies for several reasons, the simplest being that the 8086 has an odd (read: difficult to use) instruction set and architecture (I never liked segmented memory), making optimizer writing a complex task. Other reasons are poor use of registers and high overhead in subroutine calls (especially in programs whose text segments exceed 64K).

On PDP-11-type machines (where C originated), we've found that there is about a 30 percent overhead to C vs. assembler. Most system designers con-

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(continued from page 8)

sider this quite good compared to other high-level languages (even, dare I say it in the same breath, FORTRAN).

On other types of architectures, C is better or worse depending on how well the instruction set matches the operators in C, and on how much time and effort is put into the compiler design and the optimizer.

2. The paragraph that talks about the market voting with its wallet and not caring about "how hard it was to produce a program or how long it took," etc., is true in essence. Users are interested in two basic factors when purchasing software: cost and functionality. Speed is an important factor in functionality. Mr. Hardenbergh has obviously not gone to market with many products, however; otherwise he'd know that the "market window" makes or breaks a product.

A program that works, however slowly, is better than one that is still being written. Being first can be much more important than being fastest! Prototyping in C and rewriting parts in assembly language is an accepted method of software design; it also allows a product (alpha or beta version) to be placed in the market ASAP. If coding in C can reduce the development time for a product, then this may also bring down the cost so that even if the product is slower than its assembly sibling, it will be less expensive. (Somehow, this doesn't seem to happen, though. I wonder if corporate greed enters into play here?)

3. An example of an application in which C has made a firm stand is in the area of operating systems. Consider that the Unix system is about 90 percent C and 10 percent assembly (interesting that this particular ratio pops up, isn't it?); it comprises about 100K of instructions and about another 100K of data (give or take a little depending on the number of device drivers installed and the amount of memory devoted to buffer caches). Now consider that mainframe operating systems written in assembly are much larger (MVS is around 130K without TSO, which is necessary if you want to have an interactive system.)

Whether Unix is more or less functional than other operating systems is a long-standing dispute; however, in looking at Amdahl's UTS system (a Unix System V implementation for IBM mainframes), I've seen a system that can support more users than can MVS/TSO or VM/CMS on the same processor. Not only is UTS faster, but it also has a feature that no IBM mainframe has: full-duplex asynchronous communications (which we're so used to that we forget how annoying half-duplex is).

I guess that the point here is that even though Unix is coded mostly in C, it has enough functionality to make a dent in a marketplace dominated by products coded in assembly language; enough functionality to force companies to offer it as an option even though it competes with their own operating systems.

Anyway, there is no question that assembly produces faster code than C does in practically every application; the questions are whether the overhead that goes along with C is worth the reduction in development time and overall product cost and whether having the time to add greater functionality to the product is desirable.

Patrick Wood
Pipeline Associates Inc.
49 Manito Ave.
Lake Hiawatha, NJ 07034

Correction

Listing Five of Brian R. Anderson's article, "A 68000 Cross Assembler—Part 1," (April 1986) was incomplete. The complete listing is shown in Table 4, below.

DDJ

```
and b       move.b regb(regs),d0              ; A0 Ana B
            and.b rega(regs),d0
            move.b d0,rega(regs)
            and.w regconff,d0
            move.b 16(flagptr,d0.w),regf(regs)
            jmp (return)
```

Table 1: *The original AND*

```
and.b       and.b regb(regs),rega             ; A0 Ana B
            move.b 16(flagptr,rega.w),regf
            jmp (return)
```

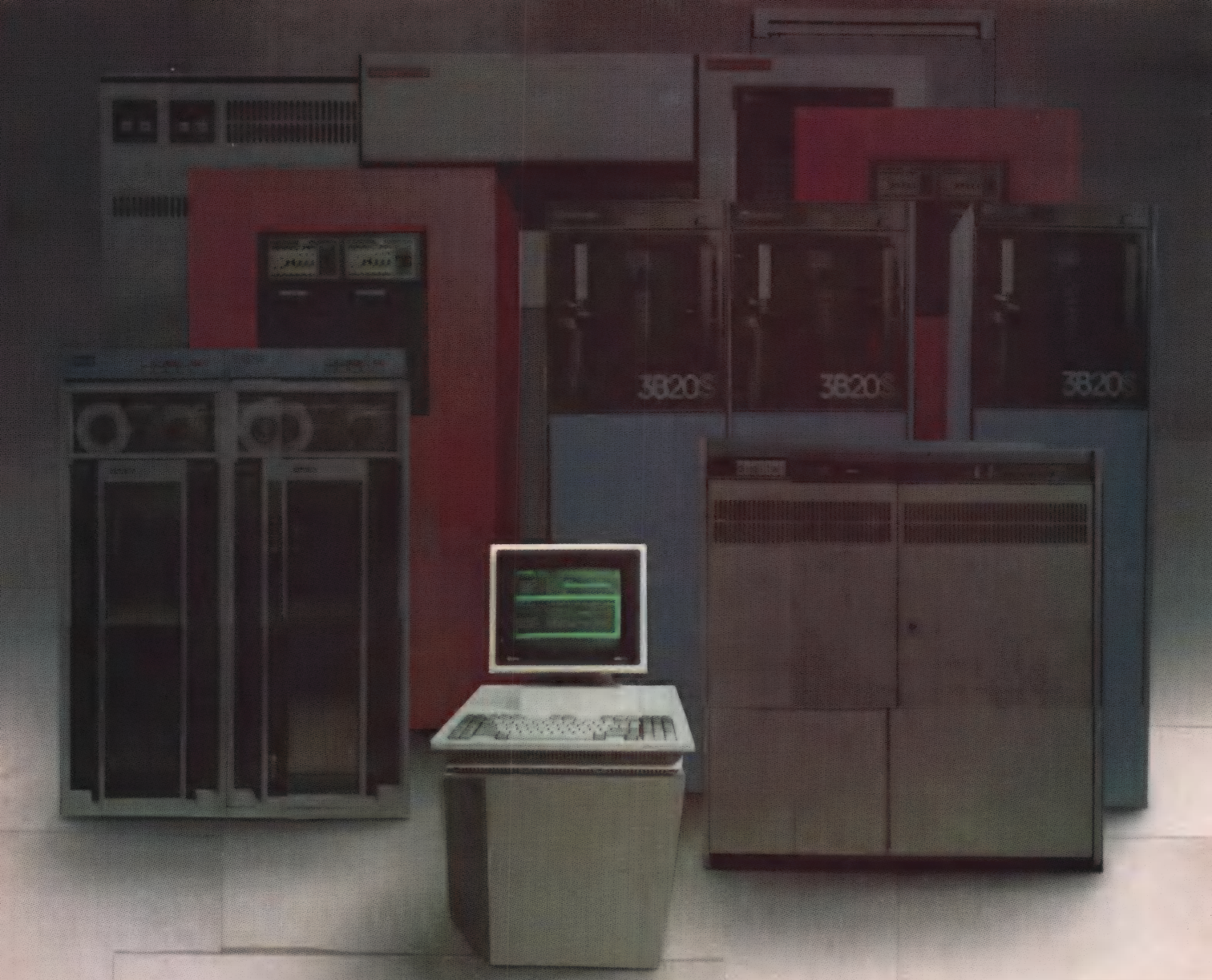
Table 2: *The improved AND*

```
call        move.w (pseudopc)+,d0
            rol.w #8,d0             ; Byte reversal, but
            move.1 pseudopc,d1
            sub.1 targbase, d1
            rol.w #8,d1             ; barrel shifter is quick!
            move.w d1,-(sp)
            lea.l 0(targbase,d0.1),pseudopc
            jmp (return)
```

Table 3: *CAll using 68020 instructions*

```
DEFINITION MODULE CodeGenerator;
(* Uses information supplied by Parser, OperationCodes, *)
(* and SyntaxAnalyzer to produce the object code.       *)

   FROM Parser IMPORT
      TOKEN, OPERAND;

   FROM LongNumbers IMPORT
      LONG;


   EXPORT QUALIFIED
      LZero, AddrCnt, Pass2, BuildSymTable, AdvAddrCnt, GetObjectCode;


   VAR
      LZero, AddrCnt : LONG;
      Pass2 : BOOLEAN;


   PROCEDURE BuildSymTable (VAR AddrCnt : LONG;
                            Label, OpCode : TOKEN; SrcOp, Destp : OPERAND);
   (* Builds symbol table from symbolic information of Source File *)

   PROCEDURE AdvAddrCnt (VAR AddrCnt : LONG);
   (* Advances the address counter based on the length of the instruction *)

   PROCEDURE GetObjectCode (Label, OpCode : TOKEN;
                            SrcOp, DestOp : OPERAND;
                            VAR AddrCnt, ObjOp, ObjSrc, ObjDest : LONG;
                            VAR   nA,      nO,      nS,      nD,    : CARDINAL);
   (* Determines the object code for the operation as well as the operands *)
   (* Returns each (up to 3 fields), along with their length              *)


END CodeGenerator.
```

Table 4



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VIEWPOINT

What's Wrong with C

by David Carew

David Carew is a systems analyst developing banking applications at Inc., 2864 South Circle Dr., Ste. 200, Cheyenne Centre, Colorado Springs, CO 80906.

Conventional wisdom is something that ought to be questioned periodically. The selection of C as the language of choice for microcomputer system software development has arguably attained the status of conventional wisdom. After all, what is good enough for Bill Gates and his crew ought to be good enough for us, right?

I realize that criticizing a programmer's favorite language is likely to provoke a defensive reaction more visceral than rational, and I expect some controversy.

My first criticism is that the code produced by most people using C as a tool is (hang on to your hat!) bulky and slow. Furthermore, it is not just bulky and slow compared with assembly language; it is inefficient compared with the output of an average production-quality optimizing compiler.

Conventional wisdom Lsays that the reward for working in an inherently low-level language such as C is efficiency. This is not necessarily so. In C, as in assembly language, optimization is the responsibility of the individual programmer. The whole C philosophy would have you believe this is the correct emphasis. Unfortunately hand optimization, like documentation, never gets done (unless of course, the product is about to become obsolete).

The brutal fact is that an average optimizing compiler will outdo the hand-coded assembler implementation of 80 percent of the programming population; the other 20 percent would take from three to ten times longer to get a better implementation up and running. A second brutal fact is that C, with its low-level philosophy and direct implementation of pointers and machine-level constructs, simply doesn't allow the use of standard compiler optimization techniques. Object code generated by a C compiler almost never beats hand-coded assembly.

If better quality compilers were demanded, better quality would be delivered. The fact that good quality optimizing compilers seem scarce in the microcomputer market should not be an excuse for sticking with C.

My second criticism of C is also directed at something usually regarded as a strength, or at least as an opportunity for the proverbial "experienced programmer": C's operator set is too rich. Taken with the operator characters in C's omnipresent preprocessor, all those special operators (++, &, *, --, and so forth) and their accompanying precedence rules form a little "language within a language." The programmer is rewarded for knowing the nuances and tricks of this "language"—rewarded with much more efficient code.

Thus guided by the invisible hand of the compiler, the programmer inevitably tends: (a) to write less understandable, less supportable code; and (b) to become distracted from the task of contriving an optimal solution to the problem at hand. I am often struck by the impression that a given C program is an elegant example of C and its operators but misses the point as a solution. On the one hand, here is a concordance generator that builds a binary tree instead of using a faster, shorter, and more robust sort, but its use of pointer operators in building the tree is expertly done. On the other hand, there is a *grep*-style search utility in which expert use of C's nuances is made in the service of a hard-wired, "look-ahead" style parser that is admittedly slower (and probably bulkier) than a good table-driven parser.

From the standpoint of the software designer, a good compiler might allow the programmer to say either

```
b = ++i
```

or

```
i = i+1
b = i
```

as long as the object code generated is the same. When one construct generates radically better code (and when there are dozens or hundreds of such tricks and trade-offs), it is natural for the programmer to expend effort optimizing his or her use of the progamming notation as well as devising an efficient solution to the problem at hand. Because the compiler is well-defined, consistent, and approachable and the application problem is likely to be ill-defined, inconsistent, and messy, it is very easy for the emphasis to become misplaced.

Make no mistake about it, better algorithms and data structures for solution of the application problem are far more important than is ideal use of a complex programming notation. To see this for yourself, benchmark a quick-and-dirty, compiled BASIC quick sort against the tightest, best-coded, C language selection sort you can devise or find.

C is tending to create a new computer elite, a barrier to those who haven't the time or inclination to master its complexity (and, devotees would say, its attendant "power"). Because the investment in learning C is so high, there is a strong psychological addiction factor. C wizards like being C wizards, and the sociology of this understandable bias may be dangerously close to creating an unnecessary, artificial barrier to further progress in microcomputer software technology.

The measure of a compiler-based programming language is in the quality of its output object code and, perhaps even more important, in the productivity of average (nongenius, nonwizard) programmers, who produce and maintain the vast bulk of all source code in any language. By these measures, C is a surprisingly poor language, given its unquestioned acceptance. It may be the best choice we have at the moment—though even that contention may be open to debate.

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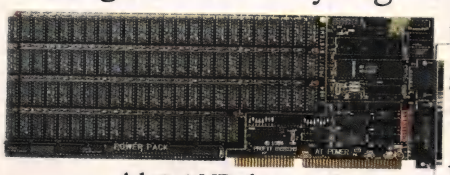

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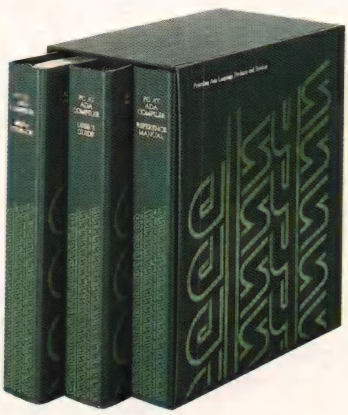

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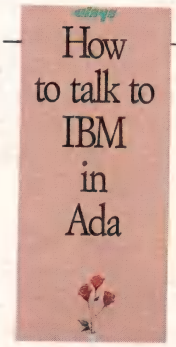

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DDJ ON LINE

The following was written and uploaded to Data Library 0 by Forum member John A. Thomas. The online discussion ignited by this article and tended by John, which is in DL0 as well (Type KEYWORDS:ENCRYPT THREAD*), is generating a good deal of heat and light. Feel free to add your comments to the message board there.*

Survey of Data Encryption

This article is a survey of data encryption. It is intended to provoke discussion among the members of this forum and perhaps lead to a creative exchange of ideas. Although the basics of the subject seem to be known to few programmers, it embraces many interesting and challenging programming problems, ranging from the optimization of machine code for maximum throughput to the integration of encryption routines into editors, communications packages, and perhaps products not yet invented. Governments have dominated this technology until the last few years, but now the need for privacy and secrecy in the affairs of a computer-using public has made it essential that programmers understand and apply the fundamentals of data encryption.

by John A. Thomas
CIS 75236,3536

Some Cryptographic Basics

A few definitions are appropriate first. We use the term *encryption* to refer to the general process of making plain information secret and making secret information plain. To *encipher* a file is to transform the information in the file so that it is no longer directly intelligible. The file is then said to be in *ciphertext*. To *decipher* a file is to transform it so that it is directly intelligible—that is, to recover the *plaintext*.

The two general devices of encryption are *ciphers* and *codes*. A cipher works on the individual letters of an alphabet, whereas a code operates on some higher semantic level, such as whole words or phrases. Cipher systems may work by transposition (shuffling the characters in a message into some new order), by substitution (exchanging each character in the message for a different character according to some rule), or by a combination of both. In modern usage, transposition is often called permutation. A cipher that employs both transposition and substitution is called a *product* cipher. In general, product ciphers are stronger than those using transposition or substitution alone. Shannon[1] refers to substitution as "confusion" because the output is a nonlinear function of the input, thus creating confusion as to the set of input characters. He referred to transposition as "diffusion" because it spreads the dependence of the output from a small number of input positions to a larger number.

Every encryption system has two essential parts: an algorithm for enciphering and deciphering and a *key*, which consists of information to be combined with the plaintext according to the dictates of the algorithm. In any modern encryption system, the algorithm is assumed to be known to an opponent, and the security of the system rests entirely in the secrecy of the key.

Our goal is to translate the language of the plaintext to a new "language" that cannot convey meaning without the additional information in the key. Those familiar with the concept of entropy in physics may be surprised to learn that it is also useful in information theory and cryptography. Entropy is a measure of the amount of disorder in a physical system or the relative absence of information in a communication system. A natural language such as English has a low entropy because of its redundancies and statistical regularities. Even if many of the characters in a sentence are missing or garbled, we can usually make a good guess as to its meaning. Conversely, we want the language of our ciphertext to have as high an entropy as possible; ideally, it should be utterly random. Our guiding principle is that we must increase the uncertainty of the cryptanalyst as much as possible. His uncertainty should be so great that he cannot make any meaningful statement about the plaintext after examining the ciphertext; also, he must be just as uncertain about the key, even if he has the plaintext itself and the corresponding ciphertext. (In practice, it is impossible to keep all plaintext out of his hands.)

A prime consideration in the security of an encryption system is the length of the key. If a short key (that is, short compared with the length of the plaintext) is used, then the statistical properties of the language will begin to "show through" in the ciphertext as the key is used over and over, and a cryptanalyst will be able to derive the key if he has enough ciphertext to work with. On the other hand, we want a relatively short key so that it can be stored easily or even be remembered by a human. The government or a large corporation may have the means to generate and store long binary keys, but we cannot assume that the personal computer user will be able to do so.

The other important fact about the keys is that there must be very many of them. If our system allows only 10,000 different keys, for example, it is not secure because our opponent could try every possible key in a reasonable amount of time. This introduces the concept of the "work factor" required to break an encryption system. We may not have a system unbreakable in principle, but if we can make the work factor for breaking so high it is not practical for our opponent to do so, then it is irrelevant that the system may be less strong than the ideal. What constitutes an adequate work factor depends essentially on the number of uncertainties the cryptanalyst must resolve before he can derive plaintext or a key. In these days of constantly improving computers, that number should probably exceed 2^{128}. It is easy to quantify the work factor if we are talking about exhaustive key trial, but few modern ciphers are likely to be broken by key trial because it is too easy to make the key space very large. Most likely they will be broken be-

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cause of internal periodicities and subtle dependency of output on input, which give the cryptanalyst enough information to reduce his uncertainty by orders of magnitude.

A corollary to work factor is the rule that a system need only be strong enough to protect the information for however long it has value. If a system can be broken in a week, but not sooner, then it may be good enough if the information has no value to an opponent after a week.

Cryptanalysis

Cryptanalysis is the science of deriving plaintext without the key information. Anyone intending to design an encryption system must be acquainted to some degree with cryptanalytic methods. The methods of attack may range from sophisticated statistical analysis of ciphertext to breaking into the opponent's office and stealing his keys ("practical cryptanalysis"). There are no rules of fair play. The cryptanalyist is free to use his puzzle-solving ingenuity to the utmost, even to the point of applying the knowledge that your dog's name is Pascal and that you might be lazy enough to use that as your key for the day.

The cryptanalyst may have only ciphertext to work with, he may have both ciphertext and the corresponding plaintext, or he may be able to obtain the encipherment of chosen plaintext. Some cryptographic systems are fairly strong if the analyst is limited to ciphertext but fail completely if he has corresponding plaintext. Your system should be strong enough to resist attack even if your opponent has both plaintext and ciphertext.

Computer power can greatly aid cryptanalysis, but many systems that appear strong can be broken with pencil-and-paper methods. The Vigenere family of polyalphabetic ciphers, for example, was generally believed to be unbreakable up until the late nineteenth century. A polyalphabetic cipher is a substitution cipher in which a different alphabet is used for each character of plaintext. In these systems, the key determines the order of the substitution alphabets, and the cycle repeats with a period equal to the length of the key. This periodicity is a fatal weakness because fairly often a repeated letter or word of plaintext will be enciphered with the same key letters, giving identical blocks of ciphertext. This exposes the length of the key. Once we have the length of the key, we use the known letter frequencies of the language to gradually build and test hypotheses about the key. Vigenere ciphers can be implemented easily on computers, but they are worthless today. Designers without knowledge of cryptanalysis, however, might be just as ignorant of this fact as their colleagues of the last century. Please see the references at the end of this article for information on cryptanalytic techniques.

A Survey of Cryptographic Systems

I'll now review some representative encryption schemes, starting with traditional ones and proceeding to the systems that are only feasible when implemented on computers.

The infinite-key cipher, also known as the "one time pad," is simple in concept. First, we generate a key that is random and at least the same length as our message. Then, for each character of plaintext, we add the corresponding character of the key to give the ciphertext. By addition, we mean some reversible operation; the usual choice is the exclusive-OR. A little reflection will show that, given a random key at least the size of the plaintext (that is, "infinite" with respect to the plaintext because it is never repeated), the resulting cipher is unbreakable, even in principle. This scheme is in use today for the most secret government communications, but it presents a serious practical problem with its requirement for a long random key for each message and the need to somehow send the lengthy key to the recipient. Thus the ideal infinite-key system is not practical for large volumes of message traffic. It is certainly not practical for file encryption on computers because where would the key be stored? Be wary of schemes that use software random-number generators to supply the infinite key. Typical random-number algorithms use the preceding random number to generate the succeeding number and can thus be solved if only one number in the sequence is found.

Some ciphers have been built to approximate the infinite-key system by expanding a short key. The Vernam system for telegraph transmission used long paper tapes containing random binary digits (Baudot code, actually) that were exclusively-ORed with the message digits. To achieve a long key stream, Vernam and others used two or more key tapes of relatively prime lengths, giving a composite key equal to their product. The system is still not ideal because eventually the key stream will repeat, allowing the analyst to derive the length and composition of the keys given enough ciphertext. There are other ways to approach the infinite-key ideal, some of which are suggested in my article (with Joan Thersites) in the August 1984 issue of *DDJ*. (See sidebar on page 20.)

Rotor systems take their name from the electromechanical devices of World War II, the best known being perhaps the German ENIGMA. The rotors are wheels with characters inscribed on their edges and with electrical contacts corresponding to the letters on both sides. A plaintext letter enters on one side of the rotor and is mapped to a different letter on the other side before passing to the next rotor and so on. All the rotors (and there may be few or many) are then stepped so that the next substitution is different. The key is the arrangement and initial setting of the rotor disks. These devices are easy to implement in software and are fairly strong. They can be broken, however; the British solution of the ENIGMA is an interesting story outside the scope of this article. If you implement a rotor system, consider having it operate on bits or nybbles instead of bytes, consider adding permutation stages, and consider how you are going to generate the rotor tables because you must assume these will become known to an opponent.

In 1977 the National Bureau of Standards promulgated the Data Encryption

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Standard (DES) as the encryption system to be used by all federal agencies (except for those enciphering data classified under any of the national security acts). The standard is available in a government publication and also in several books. The DES was intended to be implemented only in hardware, probably because its designers did not want users to make changes to its internal tables. DES has been implemented in software, however, and is available in several microcomputer products (such as Borland's SuperKey or IBM's Data Encoder).

The DES is a product cipher using 16 stages of permutation and substitution on blocks of 64 bits each. The permutation tables are fixed, and the substitutions are determined by bits from a 56-bit key and the message block. This short key has caused some experts to question the security of DES. Controversy also exists regarding the involvement of the National Security Agency in parts of the DES design. The issues are interesting but beyond the scope of this article.

Because DES was intended for hardware implementation, it is relatively slow in software. Software implementations of DES are challenging because of the bit manipulation required in the key scheduling and permutation routines of the algorithm. Some implementations gain speed at the expense of code size by using large, precomputed tables.

The public-key cipher is an interesting new development that shows potential for making other encryption systems obsolete. It takes its name from the fact that the key information is divided into two parts, one of which can be made public. A person with the public key can encipher messages, but only one with the private key can decipher them. All public-key systems rely on the existence of certain functions for which the inverse is very difficult to compute without the information in the private key. These schemes do not appear to be practical for microcomputers—at least for 8-bit machines—if their strength is to be exploited fully. One variety of the public-key system (the knapsack) has been broken by solution of its enciphering function, but this is no reflection on other systems, such as the RSA scheme, which use different enciphering functions. All public-key systems proposed to date require heavy computation, such as the exponentiation and division of very large numbers (200 decimal digits for the RSA scheme). On the other hand, a public-key system that worked at only 10 bytes/second might be useful if all we are sending are the keys for some other system, such as the DES.

Some Random Thoughts

- Must we operate on blocks instead of bytes? Block ciphers seem stronger because they allow for permutation. On the other hand, they make life difficult when file size is not an integral multiple of the block size.
- Can we make a file encryption system OS-independent? This is related to the question above on blocks vs. bits. How do we define the end of file if the plaintext is ASCII and the ciphertext can be any 8-bit value?
- Can we find an efficient way to generate and store a random key for the infinite-key system? Hardware random-number generators are not hard to build, but would they be of any use?
- Bit fiddling is expensive. Can it be avoided and still leave a secure system?
- No file-encryption system can erase a file logically and be considered secure. The information can be recovered until it is overwritten. Overwriting files adds to processing time. I am informed that it is possible to reliably extract information even from sectors that have been overwritten. Is this so? If it is, what is the solution?
- How do we integrate encryption systems into different tools? Should a telecommunications program encrypt data transparently if the correspondent is compatible? What about an editor-encryption system wherein plaintext would never exist on the disk, only on the screen? How would we manage to encipher/decipher text as we scroll through it and make changes and still get acceptable performance?
- By their nature, encryption schemes are difficult to test. What test might we subject a system to that would increase our confidence in it?

Note

1. Claude Shannon, "Communication Theory of Secrecy Systems," *Bell System Technical Journal (Oct. 1949): 656—715.*

DDJ

From the Data Library

Listings One and Two, page 66, are the 68000 versions of the permutation routines described in Z80 code in the article "Designing a File Encryption System" in the August 1984 issue of *DDJ*. Permf performs the forward permutation of the bits in a 256-bit block as specified by a table of bytes. Permg performs the inverse permutation.

For example, if the permutation table has the values

```
1 15 115 57 . . . 0
```

then the forward permutation means to put the 1st bit of the block in the 0th place, the 15th bit in the 1st place, the 115th bit in the 2nd place, and so on until the 0th bit goes in the 255th place.

The inverse permutation with the same table means to place the 0th bit of the block in the 1st place, the 1st bit in the 15th place, the 2nd bit in the 115th place, and so on until the 255th bit goes in the 0th place.

In the original cryptographic use, the permutation table was assumed to be cycled to its next permutation after the encryption of each block. I will upload the cycle routine that does this fairly soon.

The routines address bits in the block by deriving a bit index from the byte value of the permutation table. The upper five bits of that value index to the particular byte in the block, and the lower three bits then index to the particular bit within that byte.

The routines run about three times faster than the Z80 versions.

(Listings begin on page 66.)

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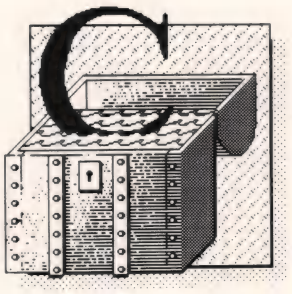

As tax time rolls around again (I'm writing this column in March), the dreaded task of organizing my tax records rears its ugly head. The year before last I used dBASE to do this organizing, and last year I used Lotus 1-2-3. Neither program is really satisfactory. It's too hard to enter data using dBASE, and the Lotus spreadsheet does just that, spread out all over my dining room table. Both programs are designed to do much more than needed anyway. All I want to do is create a normal file, with a normal editor, in which each line represents a deductible item. The line is split up into several fields (date, category, description, amount, check number), and the entire file must be sorted first by category and then by date (that is, all lines for a single category have to be grouped and the lines within the category need to be sorted by date).

So, my solution to this problem was to dust off an old sort utility and modify it so that it could handle files larger than the amount of available memory. This month, I'll discuss this program, which is called sort.

Sort sorts the lines of an ASCII file (or collection of files)—that is, the individual lines are rearranged but the words on a line aren't changed. Its command-line syntax is:

```
sort [-options] [file . . .]
```

If no files are given on the command line, standard input is used. If several files are listed, they are treated as if

by Allen Holub

they were one big file and then sorted. It's as if sort merged them all together into a single file and then sorted that single file.

Various command-line options are supported (see Table 1, page 24). These are:

-b—Ignore leading white space (blanks, tabs, form-feeds, and so on). If you're sorting on fields (see below), then white space following the field delimiter is ignored (even if the field delimiter itself is a space or tab).

-d—Sort in dictionary order. That is, all characters except letters and numbers are ignored for the purposes of comparison—for example, *hand puppet* will be between *handmade* and *handsaw* in the output.

-f—Fold uppercase letters into lowercase before comparing. Normally uppercase letters have a higher value than lowercase—*foo* will follow *Foo* in the output file.

-n—This flag is treated in a very different way from the way the Unix *sort* utility treats it. Here, if two numbers (with an optional leading - sign) appear in the same position on two lines, they are treated as a single number rather than as a collection of ASCII characters. For example, the list

```
 2
 1
20
10
```

will normally be sorted as a collection of ASCII characters, yielding

```
 1
10
 2
20
```

If *-n* is given on the command line, they'll be sorted as

```
 1
 2
10
20
```

Numbers are treated specially wherever they're found, even if they're imbedded in a word, so the list

```
word2
word1
word20
word10
```

will sort to

```
word1
word2
word10
word20
```

if *-n* is specified. Note, though, that the numbers have to be at the same relative place on the line, so

```
word  1
word  2
word 10
word 20
```

sorts to

```
word 10
word 20
words 1
words 2
```

unless *-d* is also specified.

Note that a version of *stoi( )*, the number-processing routine used for numeric processing, was originally published in the May 1985 C Chest. (See Listing Two, page 83.) The version given here differs from the original in that it's been scaled down to accept only decimal numbers (the original accepted hex and octal numbers too).

-t<c>—The single character <c>

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(continued from page 22)

specifies a field separator character (the default is a tab, thus the *t*). For example, −*t*, tells sort to use a comma as a field separator.

−p<num>—Sort field <*num*> only where fields are delimited by the character specified with the −*t* argument. The leftmost field is field 1. For example, the file

ant, bat, cow
bat, cow, ant
cow, ant, bat

when sorted with the command line

sort −t, −p2 file

will yield

cow, ant, bat
ant, bat, cow
bat, cow, ant

Only the second field, rather than the entire line, is looked at by sort.

−s<num>—Specify a secondary key. When sorting fields, if the contents of the fields specified by the primary key are the same, then the secondary field is used to resolve differences. For example, the file

ant, cow, cow
bat, cow, ant
cow, ant, bat

when sorted with the command line

sort −t, −p2 −s3 file

will yield

cow, ant, bat
bat, cow, ant
ant, cow, cow

Here, the last two lines both have *cow* in the primary sort field (field 2), so they are ordered depending on what sort finds in the secondary sort field (field 3). Given a file containing lines of the form

<date>, <category>,
<other stuff>

my tax preparation can be done with the command line

sort −n −t, −p2 −s1 ledger
>outfile

Here the −*n* causes the dates to be sorted numerically, a comma is used to separate fields (−*t,*), the primary sort field is the category (−*p2*), and the secondary sort field is the date (−*s1*). The other fields on the line are ignored. The default primary field is *1* (the leftmost) if −*s* but no −*p* is given on the command line.

−r—Do a reverse sort (sort in descending rather than ascending order).

−T<str>—The <*str*> is prefixed to all intermediate file names. Intermediate files are usually called merge.1, merge.2, and so on. If you say

sort −T/tmp/ file

then the temporary files will be called /tmp/merge.1, /tmp/merge.2, and so on. Remember to put the trailing slash on the string if you're specifying a directory name (as compared to a RAMdisk designator or whatever).

−u—Delete duplicate lines in the output. After the file is sorted, only one of a series of identical lines is output.

−b	ignore leading white space (blanks)
−d	sort in dictionary order
−f	fold uppercase into lowercase
−n	sort numbers by numeric value
−p<num>	use field <num> as primary key
−r	do a reverse sort
−s<num>	use field <num> as secondary key
−t<c>	use <c> to separate fields
−T<str>	prepend <str> to temp file names
−u	delete duplicate lines in output

Table 1: *Sort command-line options*

```
ssort(array, nel, elsize, cmp)
char        *array;    /* Pointer to array being sorted */
int         nel;       /* Number of elements in array */
int         elsize;    /* Size of one element in bytes */
int         (*cmp)( ); /* Pointer to a comparison function */
```

Ssort( ) sorts the array using a shell sort. *Cmp* is a pointer to a comparison function that acts like *strcmp( )* does. *Cmp(a,b)* must return a negative number if *a*<*b*, zero if *a*==*b*, and a positive number if *a*>*b*. It is passed pointers to two array elements. *Argv* can be sorted with

```
acmp(a, b)
char        **a, **b;
{
            return( strcmp(*a, *b) );
}

main( argc, argv )
int         argc;
char        **argv;
{
            ssort( argv, argc, sizeof(*argv), acmp );
}
```

Table 2: *Calling syntax to* ssort

Sorting Large Files

Two general-purpose sort routines have been printed in this column: a quicksort routine (*qsort( )*) was printed in April 1985 and a shell sort

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(continued from page 24)

(*ssort( )*) was printed in March 1986. Both algorithms were discussed in the April 1985 column. The *qsort( )* subroutine is also included in many compilers' I/O libraries. All these routines have an identical calling syntax so they can be used interchangeably.

These sort routines all have one major limitation. The entire array being sorted has to be in memory at once. Sometimes you need to sort files that are larger than the amount of available memory, however. This limitation is circumvented by using temporary merge files. Sort reads as much input as it can, sorts that input, and then writes the sorted lines to a temporary file. It continues in this manner until the input is exhausted, creating a bunch of temporary files, one for each pass. The program then merges the temporary files, writing the results to standard output. Finally, the temporaries are deleted.

The process is best illustrated with an example. Say that at most three input lines can be held in memory and a file containing

```
good
every
boy
favor
deserves
```

has to be sorted. Sort reads in the first three lines, sorts them, and then creates a temporary file. It then repeats the process with the remaining two lines. The temporary files look like

```
MERGE.1        MERGE.2

boy            deserves
every          favor
good
```

They are both sorted. The program now merges the files. It reads in the first line of each merge file

```
boy
deserves
```

outputs the lesser line (*boy*) and replaces it with the next line from the temporary file that originally contained *boy* (merge.1):

```
every
deserves
```

The program now repeats the same process on the two current lines, outputting *deserves* and replacing it with the next line from merge.2:

```
every
favor
```

every is output and replaced by the last line in merge.1:

```
good
favor
```

favor is now output. Because merge.2 is now empty, no input is fetched and the list contains the single word *good*, which is output in turn. Because all merge files are now empty, the program ends.

The same process can be used when there's more than one merge file. The program reads in one line

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QNX vs UNIX

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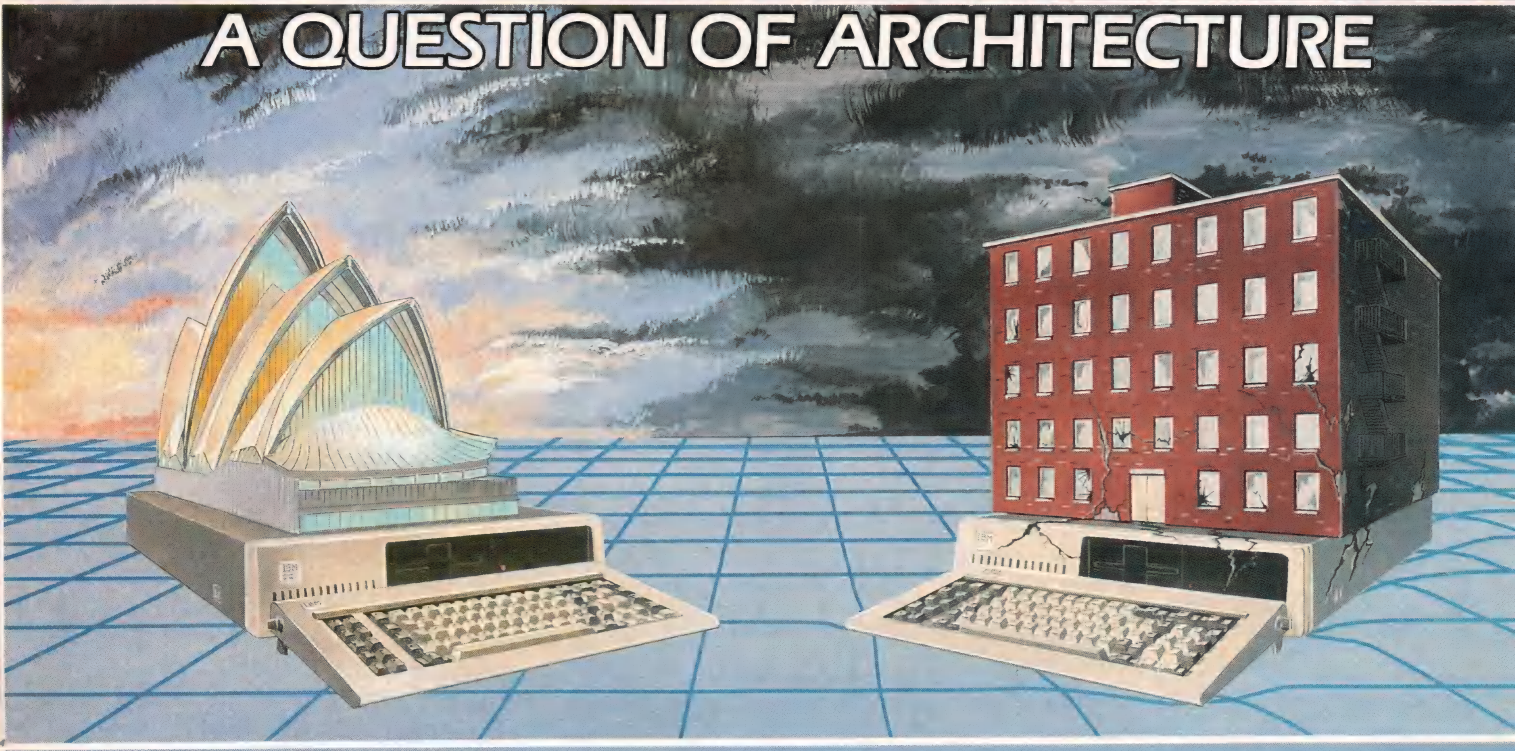

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(continued from page 26)

from each file, outputs the line having the lowest value, and then replaces that line with the next line from the appropriate merge file, continuing the process until all the merge files are empty.

The problem here is selecting the line having the smallest value. The simplest method is to keep an *argv*-like array of pointers to strings, where each string is one line from a merge file. The array is sorted on each pass, and the lowest element is output. Sorting the array each time isn't very efficient, though. You're constantly resorting an almost-sorted array. A better way to store the lines is in a data structure called a *heap*. A heap is an array that has the property that the Kth element is always less than the (2K)th and (2K+1)th elements. For example, *array[1]* is less than both *array[2]* and *array[3]*, *array[2]* is less than both *array[4]* and *array[5]*, *array[3]* is less than both *array[6]* and *array[7]*, and so on. You can look at a heap as a sort of binary tree, where the Kth element is the parent node and the (2K)th and (2K+1)th elements are the children. All sorted arrays are heaps; on the other hand, a heap is not necessarily a sorted array.

Heaps have two additional properties that are of use here: The first element is always the smallest element, and a new element can be inserted in the heap in O(logN) time, where *N* is the heap size.

Implementation Details

Sort is presented in Listing One, page 68. Various *#defines* are on lines 18–28. *MAXBUF* is the maximum line length (now 132 columns). Lines longer than this will be treated as if they were two lines. *MAXLINEC* (now 1024) is the maximum number of input lines than can be read before a merge file is created. *MAXTMP* (now 18) is the maximum number of temporary files that can be open at once. This number is limited by either your compiler or the operating system. Two file descriptors are needed for *stdout* and *stderr*, so I'm assuming here that 20 files may be open at one time. This assumption isn't true in some CP/M systems that only allow

eight files. In DOS, to have 20 file descriptors available, you must say

files=20

in your config.sys file. It will speed up your I/O to put

buffers=20

up there too.

The global variables on lines 36–45 are all set by *getargs( )*, depending on what it finds on the command line. (The source for *getargs( )* isn't in the listing; see below for availability.) The *Argtab* on lines 47–61 is also used by *getargs( )*. Global variables not concerned with command-line switches are declared on lines 70–88. *Options* is set to true by *main( )* if any of the command-line switches that affect the sort order are present. *Lines* and *Linec* are used in the same way as *argv* and *argc*. *Lines* holds pointers to the input lines read in during the initial sorting passes (not the merge passes). *Linec* is the number of valid lines in *Lines*. *Argv* and *Argc* are just global copies of the *argv* and *argc* used by *main( )*.

The *HEAP* structure defined on lines 80–85 is used to define the heap needed in merge-file processing. You need to remember two things about every heap entry—the contents of the current line in the merge file and the *FILE* pointer associated with that merge file. So you use a structure having two fields: *string* and *file*. The heap itself is an array, *MAXTMP* elements long, of pointers to *HEAP* structures. I chose to use an array of pointers rather than an array of structures because it takes much less time to exchange two pointers than it does to exchange two, rather large, structures. This pointer array is created using *malloc( )*, and it is pointed at by the global variable *Heap* (defined on line 87).

The routine *pheap( )* (lines 95–108) is a debugging routine that prints out the current heap contents. Note that if *DEBUG* isn't *#defined*, then *pheap( )* will be *#defined* as a null macro (one that expands to a null string). This way you don't have to put *#ifdef DEBUG/#endif* directives around all the calls to *pheap( )*.

Lines are read into memory by *gtext( )* (line 358f). It loads the input lines into an *argv*-like array of pointers to strings (*Lines*). The routines that call *gtext* don't know that it may be getting input from several files (as listed on the command line). *Gtext* [or rather *nextfile( )* (line 324f), which is called by *gtext( )*] takes care of all the *argv* processing needed to open and read the various files when appropriate.

Skipping forward, the initial sorting of the *Lines* array is done by the call to *ssort( )* on line 617. The calling syntax for *ssort( )* is shown in Table 2, page 24.

The beauty of passing a pointer to a subroutine becomes obvious when looking at a routine such as *ssort( )*. Not only can an array of pointers to strings be sorted with the routine shown in Table 2 but also a more complicated sort (such as the one required by my sorting program) can be performed by the same sort subroutine. Just pass it a pointer to a more complicated comparison function. The comparison function used here is actually several subroutines defined on lines 172–320. *Argvcmp( )* (line 172f) is used when

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C CHEST
(continued from page 29)

no command-line switches that affect the sort order are specified; *qcmp( )* (line 180f) is called when command-line switches are specified. Both routines are passed pointers to string pointers (that is, the addresses of two elements of *Lines*) and both call a workhorse function to actually do the work. *Argvcmp( )* calls *strcmp( )* after stripping off one level of indirection; *qcmp( )* calls *qcmp1( )* (line 194f), which in turn calls *qcmp2* (line 228f). The former takes care of sort fields, whereas the latter does the actual comparisons—doing things such as skipping white space, mapping uppercase into lowercase characters, and so forth—as specified by command-line switches.

Once the lines are sorted, they are written out via the subroutine *outtext( )* (line 422f). *Outtext* will write to standard output if no merge files need to be created; otherwise it will write to a temporary file. It outputs the entire *Lines* array and deletes the memory used by the strings themselves (as compared to the memory used by the pointers to those strings).

As the last step in the sort, all the temporary files are merged together and the result sent to standard output. The actual merging is done in *merge( )* (line 542f). The routine *open_mergefiles( )* (line 455f) creates the heap, opens all the merge files, and reads the first line from each merge file into the heap. The heap is then initialized with the *ssort* call on line 546 (remember, a sorted array is a legal heap). The *while* loop on lines 548–566 prints the smallest element of the heap (the one pointed to by **Heap*) and then reads another line from the appropriate file. If there are no more lines to read, the file is closed and the heap is made smaller by copying the entire heap, overwriting the first entry, and decrementing *nfiles*. Finally, *reheap( )* is called to put the new entry at its proper place in the heap.

Reheap( ) (line 507f) reorders the heap in a manner similar to a binary-tree search (except that *reheap( )* isn't recursive). It compares the parent element to the two children and, if the parent is smaller than a child, transposes the two elements. The process is then repeated with the newly transposed child used as the parent node. This way the new entry percolates to its proper position in the heap. Unlike other "percolating" strategies, such as bubble sort, *reheap* is efficient, using at most $\log_2 N$ swaps, where N is the heap size rounded up to the nearest power of 2.

Limitations

There are practical limits on the amount of data that can be sorted. Because each merge file can contain at most 1,024 lines and 18 merge files are permitted, only 18,432 lines can be sorted (split up into as many input files as you like). Another consideration is the amount of space available to *malloc* (about 58K in my version of sort). Again, because this number limits the size of a merge file, there can be no more than 58K × 1,024 bytes in the combined source files (about a megabyte). Of course this last number will vary a little depending on the line lengths, but it's close. In practice, these limits haven't been a problem, but you may need to go to a large-model version of this program (to increase the amount of space available from *malloc*) or use a more sophisticated merge algorithm.

Availability

The source code for the entire program this month (including the *getargs( )*, *ssort( )*, and *stoi( )* routines) is available on CompuServe in the DDJ Forum. It's also available on an IBM PC-compatible disk for $25 from Software Engineering Consultants, P.O. Box 5679, Berkeley, CA 94705. The disk comes with an executable version and source code.

Getargs( ) and *stoi( )* were originally published in the May 1985 C Chest; *ssort( )* was published in the March 1986 C Chest. The source for all three routines is also available as part of the /Util utility program package. It costs $29.95 and is available from *DDJ*. (See the ad in the *DDJ* ad catalog in this issue, page 73.) **DDJ**

(Listings begin on page 68.)

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How to Fix Line Glitches

by Joe Marasco

Forward error correction deals with data-transmission errors by correcting them as the data are received.

Most telecommunications users are accustomed to getting error-free messages when moving blocks of data during file transfer operations. This situation differs greatly from normal bulletin board operations or from using a remote computer interactively. In these situations, most people don't even flinch when Ma Bell routes their call over barbed wire, and the ubiquitous ~ appears. Glitches on the line are almost taken for granted, and rightly so, because the "error" is obvious and immediately discounted. When transferring files, and in particular binary files, however, one bit error can be fatal, and more important, there is no easy way to detect it. It is for this reason that error-checking mechanisms are a fact of life in the telecommunications world.

The most common forms of error checking are the simple parity check and the CRC (cyclical redundancy code) check. *(For an extensive discussion of CRC techniques, see Terry Ritter's article, "The Great CRC Mystery," in the February 1986 issue of* DDJ.*—ed.)* In these schemes, one or more bits are computed when each block is sent; the block then contains the message bits and the appended computed bits. The receiver recomputes the check bit or bits using the message bits only and compares the result to the computed bits sent. If they match, an ACK is sent to the transmitter. If there is no match, a NAK is sent. The transmitter must then send the block again. CRCs provide a high degree of robustness for a small overhead.

In some applications, however, retransmissions are prohibitively expensive. When data is coming from very far away—say, from Saturn—and in large blocks, the time lag to resend the block can be significant. If the data has a real-time aspect to it, retransmission can in effect be worthless because, by the time it is evident that old data needs to be resent, new data may already be in the queue.

Forward error correction addresses these problems. The key idea is that by giving up some of the transmission bandwidth — sacrificing more message bits for overhead bits—we can not only detect the presence of an error but also correct the error at the receiver. The basic notion is that we never do a retransmission; we design the system subject to a known noise environment such that we can "fix" all "broken" packets when we get them.

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Single-Bit Errors

Let's demonstrate this principle with a concrete example using the simplest of these codes, the Hamming code.[1] The Hamming code enables you not only to detect the presence of one bit error in a block but also to locate its position and hence correct it. For now let's assume we are only concerned with single-bit errors.

For the sake of example, let us assume that we are going to transmit a 15-bit block. It turns out (we'll show you how later) that it takes 4 bits of "parity" check for a Hamming code for this block size, so we have only 11 bits of data left for the "message." Although this is a high overhead, it is purely a result of having such a small block; the situation improves radically as we go to larger blocks. We use a small message here for ease of exposition.

Because we are going to send 15 bits, we are going to have to localize the bit error to one of 15 positions. If we make a table of the 15 positions and their binary representations, we can add a third column that addresses the question of which one of the four parity checks should be applied to each bit. (See Table 1, page 33.)

Notice that the entries in the parity check column are unique, as well they should be. All we have done really is to say that if the "one bit" is in error, it will affect all the "positions" that have a "one bit," and so on. We can rewrite Table 1 by noting explicitly which bits or positions are governed by each parity check (C1, C2, C3, or C4), as shown in Table 2, page 33.

We're now almost ready to encode a message! The trick is to reserve bits 1, 2, 4, and 8 for the check bits, leaving 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, and 15 for the message bits. Let's also decide that the total number of bits governed by any

check must be even. Here's an arbitrary message:

```
 1   2 3   4 5 6 7   8 9 10 11 12 13 14 15
C1 C2 1 C3 0 1 1 C4 0  1  1  0  1  0  1
```

Now let's compute C1, which is governed by the parity of the bits shown in Table 2. Looking at the odd bits from 3 to 15, we count five 1s, so for the parity to be even, C1 must be a 1. Our message now looks like this:

```
1   2 3   4 5 6 7   8 9 10 11 12 13 14 15
1 C2 1 C3 0 1 1 C4 0  1  1  0  1  0  1
```

To compute C2, we do the same thing for the bits listed under C2 in Table 2. Looking at all the bits except for 2, which we are trying to find, we count six 1s, which is even. So C2 must be a 0. This yields:

```
1 2 3   4 5 6 7   8 9 10 11 12 13 14 15
1 0 1 C3 0 1 1 C4 0  1  1  0  1  0  1
```

You can do C3 and C4 by yourself. The final block, containing the message and check bits, should look like this:

```
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
1 0 1 0 0 1 1 0 0  1  1  0  1  0  1
```

So the message sent would be "101001100110101."

What happens at the receiver? Clearly, if the message is received with no errors, each parity check will pass, and, by definition, we ascribe a 0 to a good parity check. When we make a number out of the four binary digits from the parity check, we get 0000 for the location of the error. This value is called the syndrome; a zero value for the syndrome means there were no errors.

Now let us suppose that an error is made in transmission. Suppose that the error occurs in the fifth bit sent. Our table then looks like the one shown in Table 3, right. Applying the parity checks as given in Table 3, one by one, we have the table shown in Table 4, right. And when we construct the syndrome (C4C3C2C1), we get

0101 −> 5 −> error is in the fifth bit

So now we know that all we have to do to correct the message is to invert the fifth bit, making it a 0 instead of a 1. The original message is recovered.

There is something very nice about the Hamming code and all forward error correction codes in general. Note that once the encoding is done, there is a total equality between the original message bits and the computed check bits. It doesn't matter at all if during the transmission a data bit or a check bit gets squashed—they are all on an equal footing. If a check bit gets reversed, it will be corrected; in effect the original message gets through OK and doesn't need "correcting."

Two-Bit Errors and More

What happens with this simple code when two bit errors occur? Try it! You'll find that 2-bit errors in the channel will cause the decoder to "miscorrect," introducing yet a third bit in error. This is indeed a sad state of affairs.

At the cost of one additional check bit we can improve the situation, however. Let the zeroth bit be the total parity after the other 15 bits have been encoded. Now we have an interesting situation. If the syndrome is zero and the parity bit is OK, we have a good message. If we have one bit error in the 15 bits, we have a nonzero syndrome and a bad parity bit; we can locate the bad bit as before. If just the parity bit itself gets reversed, the syndrome will be zero, so we'll know it's just the parity bit. Finally, and most important, if there are 2-bit errors anywhere, we will get a nonzero syndrome and a good parity bit. That is the unmistakable signature of a 2-bit error. So what we now have is much better: a code that corrects any single-bit error and detects all 2-bit errors.

To let you try this out, I've written a blatant hack. (See Listing One, page 84.) You input an 11-bit message, and the program computes and displays the completed 16-bit block that would be transmitted. You can then type in the "received" message, corrupting one or more of the bits, and the decoder will tell you which bit is in error and display the corrected message.

We've just scratched the surface. Hamming codes are the first step in doing forward error correction. You've

Position	Binary Representation	Parity Check
1	0 0 0 1	1
2	0 0 1 0	2
3	0 0 1 1	1, 2
4	0 1 0 0	3
5	0 1 0 1	1, 3
6	0 1 1 0	2, 3
7	0 1 1 1	1, 2, 3
8	1 0 0 0	4
9	1 0 0 1	1, 4
10	1 0 1 0	2, 4
11	1 0 1 1	1, 2, 4
12	1 1 0 0	3, 4
13	1 1 0 1	1, 3, 4
14	1 1 1 0	2, 3, 4
15	1 1 1 1	1, 2, 3, 4

Table 1: *The bit position itself tells which parity checks to apply.*

```
C1 −> 1, 3, 5, 7, 9, 11, 13, 15
C2 −> 2, 3, 6, 7, 10, 11, 14, 15
C3 −> 4, 5, 6, 7, 12, 13, 14, 15
C4 −> 8, 9, 10, 11, 12, 13, 14, 15
```

Table 2: *Each parity check affects a unique set of bit positions.*

```
1  2  3  4  5  6  7  8  9  10  11  12  13  14  15
1  0  1  0  0  1  1  0  0   1   1   0   1   0   1 xmit
               E
1  0  1  0  1  1  1  0  0   1   1   0   1   0   1 recvd
```

Table 3: *Here a transmission error occurs at bit position 5.*

```
C1 −> 1, 3,  5,  7,  9, 11, 13, 15 −> fails −> 1
C2 −> 2, 3,  6,  7, 10, 11, 14, 15 −> passes−> 0
C3 −> 4, 5,  6,  7, 12, 13, 14, 15 −> fails −> 1
C4 −> 8, 9, 10, 11, 12, 13, 14, 15 −> passes−> 0
```

Table 4: *The parity checks locate the error (0101 = 5 in binary).*

probably deduced by now that you can correct $2^m - 1$ bits of total information with m bits of parity check (subject to only 1-bit errors, of course!). So with 10 bits set aside to do the checks, you have 1023 − 10, or 1013 bits of information sent. Even if you include the additional parity bit for 2-bit errors, this represents an overhead of about 1 percent, which is not bad when you consider that you will correct all 1-bit errors at the receiver and detect blocks with 2-bit errors.

The real power of forward error correction comes from being able to do better, however. More complicated codes can correct not only single-bit errors but also multiple-bit errors. And, because for some channels the predominant mode is not single-bit errors but errors that come in bunches, there are codes that are better suited to correcting burst errors. There are also codes that handle both single-bit errors and multiple bursts. If you are interested, you can learn more by looking up the BCH and Reed Solomon codes in the references at the end of this article.

One Last Note

Communications is often thought of as getting information from here to there. Another way of looking at it is getting information from then to now—that is, all these forward error correction schemes can be applied to disk writing and reading. When you fetch a block from a disk, good disk controller software can do an FEC maneuver and fix up the block if it was written or read incorrectly.

Use of these schemes enables the cost of disk hardware to come down because lower precision mechanical assemblies can be used; systems can be designed to have higher rates of read/write errors if we know we can correct for them. Perhaps the most stunning demonstration of this phenomenon is the audio compact disc player. The digital music that is retrieved is encoded with a sophisticated Reed Solomon forward error correction code that enables magnificent sound with less than perfect media. That you can buy one of these at less than $200 is a remarkable example of intelligent hardware and software integration.

Note

1. R. W. Hamming, *Coding and Information Theory* (Englewood Cliffs, N.J.: Prentice-Hall, 1980).

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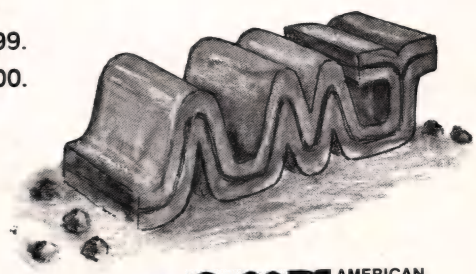

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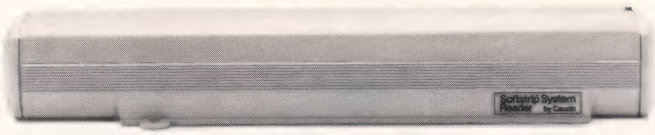

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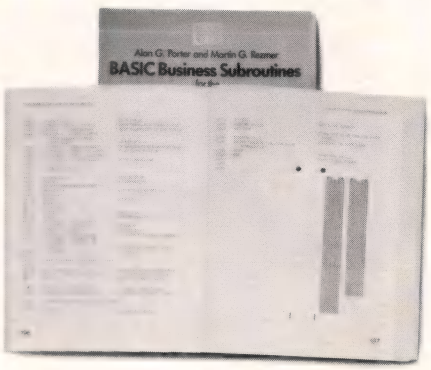

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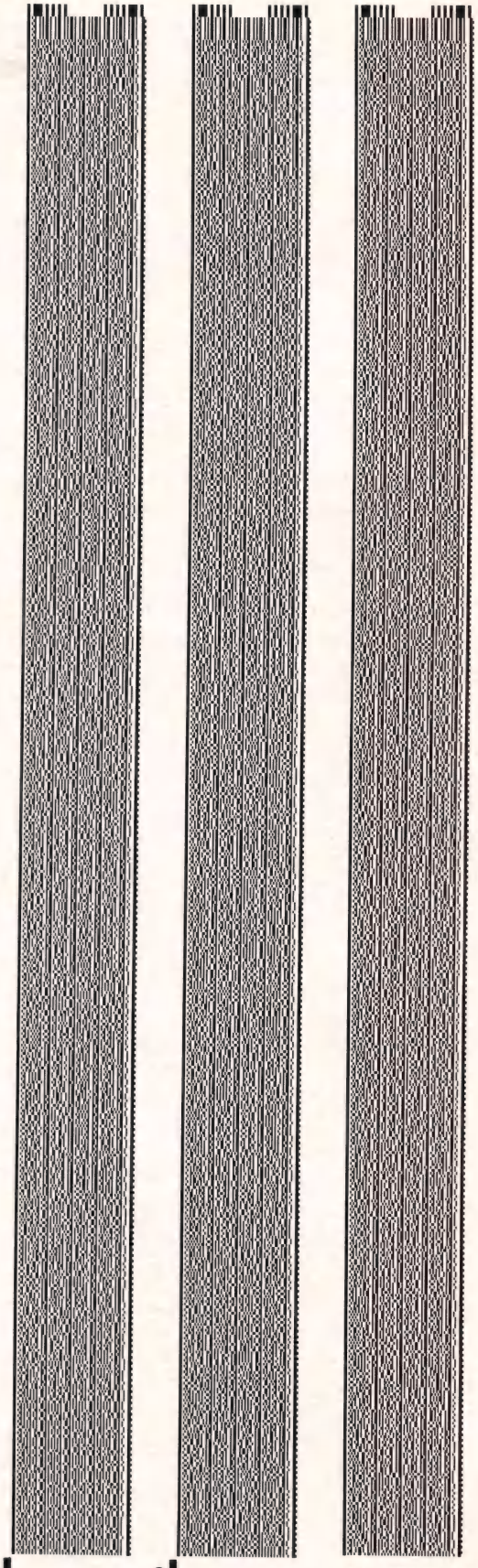

Someone once said that there is nothing new under the sun. Wouldn't life be boring if that were indeed true? The data strips on the right contain the program described in the article "The Game of Life in Expert-2", by Jack Park, which appears in this issue. It's a prime example of how something, in this case the game of **LIFE** itself, can, indeed be improved.

The game of **LIFE** was invented years ago by John Horton Conway. Over the years, the game has evolved into a popular cerebral exercise for programmers and math majors alike. At first the game was played on graph paper, but the advent of modern technology moved it to the computer which plays the game thousands of times faster. Now millions of computer enthusiasts are captivated by this devilishly simple, yet marvelously complex quintessential computer diversion.

The rules of the game are quite simple. Imagine that you have an infinite grid of squares, each one being either alive (on) or dead (off). Each square (called a "cell") lives or dies into the next cycle (called a "generation") based on its current state and that of its neighbors. The grid of cells is represented by a graphic display on your computer screen. After setting up an initial configuration of living and dead cells, you start the simulation. The patterns will change on the screen as cells live and die.

Mr. Park's improvement on the theme is interesting because of his approach. Instead of writing a traditional program for the simulation, he has created an array of intelligent cells using an inference engine written in Expert-2, a superset of FORTH.

Read in the data strips, following the directions that came with your Cauzin reader. You'll need the Expert-2 programming environment to operate this program. Refer to Mr. Park's article in this issue for operating instructions.

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Softstrip

The CompuServe B Protocol: A Better Way to Send Files

by Levi Thomas and Nick Turner

With the B protocol, unlike the others, you let the mainframe do all the work.

Talking to the Big Boys

If you've tried to use a commercial telecommunications package to upload or download files to or from a mainframe computer, you may have experienced a few difficulties. The most popular file-transfer protocols all have problems dealing with the "big boys"—XMODEM, for example, has a tendency to "time out" when the host system experiences a momentary delay in transmission. Other problems also get in the way. Many protocols require a file length that is an exact multiple of some block size. We've run into these problems here at *DDJ* while uploading listings for the DDJ Forum on CompuServe.

In 1980, a programmer at CompuServe wrote one of the first programs that tried to fix some of these problems, calling it the CompuServe A protocol. It had numerous glitches and design problems. The B protocol, designed about the same time as Ward Christensen designed XMODEM, is the next generation. For a while CompuServe afficionados wanted to keep both the A and B protocols proprietary, but CompuServe B is now in the public domain, supported by CompuServe. Because it was designed with the idea of communicating between micros and mainframes over packet-switching networks, it incorporates several improvements that largely eliminate the problems of the other protocols. With the B protocol, unlike the others, you let the mainframe do all the work.

With the B protocol, the host (usually a mainframe) activates the protocol in your micro automatically, as soon as you have invoked the protocol through your commands to the host. You must have a terminal program running in your local system that recognizes the host's initial B protocol query and automatically invokes its own "slave" program to accept or supply the data. The host also has the ability to interrogate your micro to find out what features your program supports. B protocol supports error-corrected file transfer between computers, chiefly text file transfer between microcomputers and mainframes and binary file transfer between microcomputers with possible intermediate storage on mainframes. B protocol can transfer files of arbitrary size and supports character mapping on text transfers.

The program we describe in this article is a dumb-terminal emulator with just enough intelligence to recognize when the host is about to transfer a file up or down. It responds to the host's queries and implements the protocol transparently to the terminal user. BP.C (Listing One, page 90), the vanilla version described and supplied here in C source form, is not machine specific and should be installable in most existing terminal programs, provided you have access to the source code or information on how to connect new device drivers. We've also included some machine-language and C modules for the interface routines that will work on most MS-DOS machines.

How It Works

To transfer a file using the B protocol, first you invoke it in the host system (usually the mainframe you're calling) by sending the proper commands to it manually through your terminal interface. On CompuServe this would mean selecting the proper choice from the menu. Then the host system sends the ASCII *ENQ* character, to which your terminal program responds with *DLE 0* (data link Escape followed by an ASCII *0*). The host is acting as the master in this exchange (even though the protocol was invoked by you) because it is invoking the slave process in your micro.

Next, the host usually sends the sequence *ESC I* (Escape followed by ASCII *I*). Upon receipt, the microcomputer terminal software should transmit an identification string to the requesting computer. The identification string consists of the pound sign (#), followed by a three-letter, alphanumeric, product name code (in this case the code is *DTE*, meaning a general terminal device), a version number in decimal, a comma (,), and a comma-separated list of feature codes. The feature code list details the features supported by the particular terminal program. The codes that denote a B protocol driver are *PB* (which refers to protocol B) and *DT* (disk transfer). Additional feature codes describe other capabilities, in-

cluding terminal type and graphics support.

To start the transfer, the host sends a *DLE* followed by ASCII *B*. At this point, the main terminal loop should call *Transfer_File* (a BP.C routine) to complete the protocol sequence. *Transfer_File* returns a Boolean value indicating the success/failure of the transfer.

Routines You Provide

In order to use the program supplied here, you must provide some routines for your specific hardware. You'll need four routines to control your modem or serial port. These are used by BP.C to open, read, write, and close your modem port. You'll need a couple of routines to deal with your local keyboard and screen. The program will call them to read a character from your keyboard, to write a character to your screen, and to find out if you have decided to abort the program (for example, by pressing the Esc key). You'll need to supply two timer routines: one that sets a time out of a certain number of seconds and another that tests whether the time is up. If you don't have a hardware timer, you can simulate the effect simply by decrementing a count every time the time-out routine is called. Finally, you'll need a set of file-manipulation routines whose format will be largely dependent on exactly what operating system you're running under and what library routines you're using.

Modem Interface Routines

Open_Modem—is required to initialize the modem port to support 8-bit data without auto XON/XOFF recognition before BP.C is called. No parity checking should be done. BP.C does not depend on baud rate and stop-bit settings. **Note:** Depending on the particular machine, data may be lost when the modem port is reprogrammed for no auto XON/XOFF recognition. This data loss usually affects only the first block, which the slave software can request to be retransmited by sending a NAK.

Write_Modem—is called by BP.C. Its argument is an 8-bit character to be transmitted.

Read_Modem—is called by BP.C and returns an integer containing an 8-bit character or −1. The latter is used to indicate that no character has been received over the modem port.

Close_Modem—is required to shut down the modem port outside BP.C and to restore the machine to its original state. Certain changes made in *Open_Modem*, such as reprogramming interrupt vectors, must be undone before you exit from the program.

User Input/Output Routines

Read_Keyboard (from KEYBOARD .ASM, Listing Two, page 99)—returns an integer containing either ASCII-key codes, function-key codes, or −1 for no key pressed.

Wants_To_Abort (from DTE.C, Listing Three, page 100)—is called by BP.C to detect if the user has requested abort. The routine returns a Boolean *true* if abort has been indicated. Once the *Wants_To_Abort* status has been read, the status is reset. You may notice some delay before the abort request is acknowledged. The delay is because of the need to synchron-

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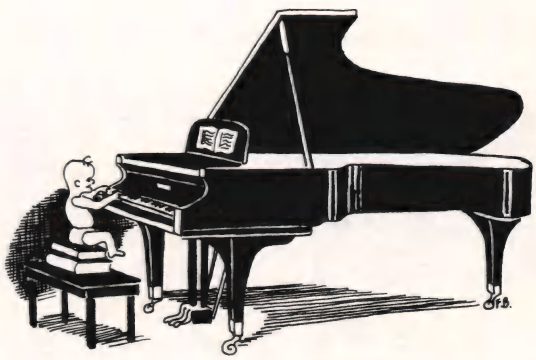

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ize the abort packet with the current protocol packet.

Put_Char (from SCREEN.ASM, Listing Four, page 104)—accepts an integer containing ASCII character codes. The characters are displayed to the user.

Timer Routines

These are routines from TIMER.ASM, Listing Five, next month.

Start_Timer—is passed an integer argument of the number of seconds to begin counting down.

Timer_Expired—returns Boolean *true* if the number of seconds set with *Start_Timer* has elapsed. If you don't have a real-time clock or timer, *Start_Timer* should set a delay counter that *Timer_Expired* decrements each time it is called, so that the number of calls to *Timer_Expired* controls time out. *Timer_Expired* is called frequently during time-out detection.

Delay (from DELAY.C, Listing Six, next month)—is called with an integer argument for the number of milliseconds to wait before returning to the calling routine. The only purpose of *Delay* is to support a wait acknowledgment request from the other computer. The wait acknowledgment can be used to request delay time needed during intensive processing.

File Input/Output Routines

These are routines from FILEIO.ASM, Listing Seven, next month. These file primitives are used to create, read, and write both text and binary files. The data should be transferred unmodified (except in character-mapping mode). The file-access mode should allow access to each byte in the file, often called "binary" or "raw" mode. The actual arguments of each of the file input/output routines will need to be those supported by the particular library you are using.

Create_File—attempts to create a file with the name supplied and returns a negative-result code (for errors) or a file handle.

Open_File—opens the file, returning a negative error code or the file handle.

Read_File—reads the specified number of bytes from the open file into the specified buffer, returning a negative error code or the number of bytes actually read.

Write_File—writes the specified number of bytes from the open file into the specified buffer, returning a negative error code or the number of bytes actually written.

Close_File—closes the file, returning a negative error code or 0.

The B protocol is not perfect, but for this application, it's clearly an improvement over the previous micro-to-micro protocols. Currently, only CompuServe supports the B protocol. The master program will eventually be available in the public domain as is the slave program presented here.

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(Listings begin on page 90.)

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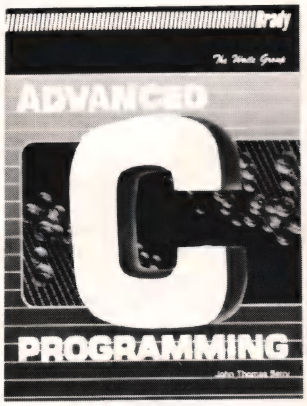

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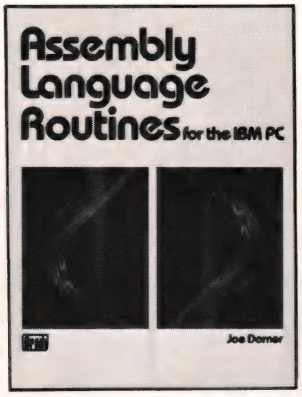

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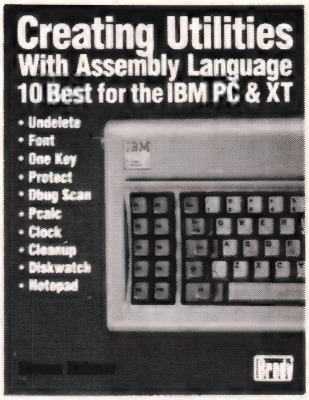

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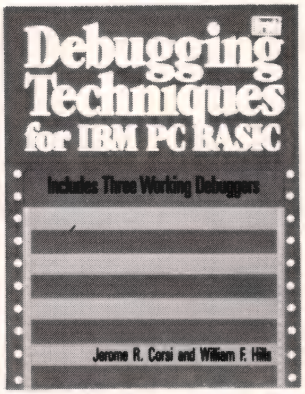

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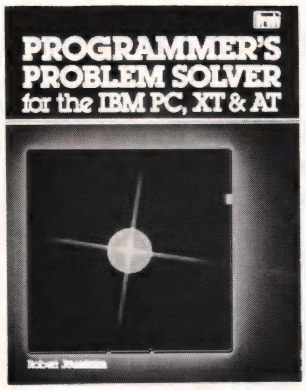

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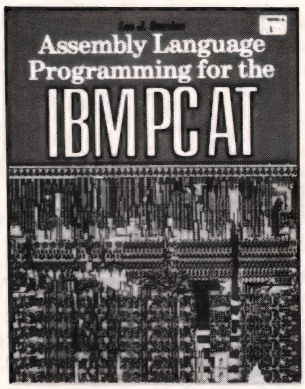

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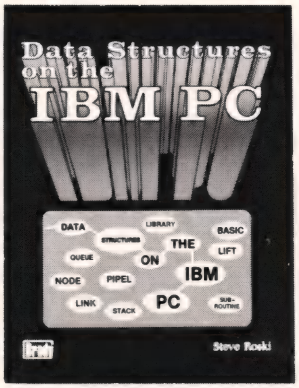

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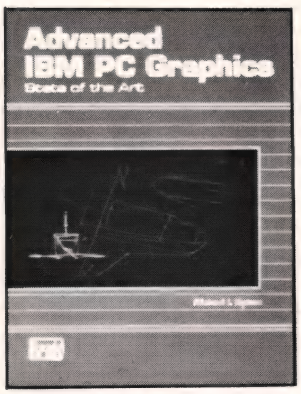

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by Dave Caulkins

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The SwyftCard from Information Appliance is a new personal computer environment for the Apple IIe and IIc. It provides a word processor from which you can easily perform other tasks, such as disk file access, calculations via BASIC, printing, and communications with a modem. The environment is noteworthy because it is philosophically at odds with the popular interface made of icons, windows, and mouse that is used on the Macintosh and other computer systems. Significantly, SwyftCard's designer is Jef Raskin, one of the initiators of the Macintosh project at Apple Computer.

I tested SwyftCard on an Apple IIe, but as this issue goes to press, Information Appliance has announced a version for the IIc also. To use SwyftCard on a IIe, you need an 80-column card, a video monitor suitable for 80-column display, and a disk drive. The SwyftCard supports a wide variety of printers; several require no setup, and many can be installed by using the Calc command.

SwyftCard consists of a three-chip board that plugs into slot 3, a set of stick-on labels for several keys, a tutorial disk, and an excellent manual. The tutorial will help you get started with SwyftCard by guiding you through a series of short lessons on the use of its features.

The word processor is the heart of the SwyftCard system. It has been carefully designed to achieve several goals:

- Speed: For text processing and floppy-disk access, SwyftCard is significantly faster than more expensive systems. All the text is in RAM, so disk access time doesn't slow SwyftCard down. Half the system is implemented in tokenized Forth and half in assembly language, resulting in fast operation. Each SwyftCard file occupies a single floppy disk and can expand to 40,000 characters, or roughly 14 pages of single-spaced text. Disk operations take less than seven seconds in all cases.
- Simplicity: There are only ten basic commands: Insert, Delete, Print, Leap, Creep, Page, Calc, Print, Send, and Disk. The last three are for input/output and are not used as frequently as the others. Most commands are implemented with one or two keystrokes using a few dual-purpose, specially labeled, SwyftCard function keys. After a little practice, users learn the commands, and text processing becomes fast and easy.
- Optional environment: You can load an ordinary Apple disk, and the operating system works normally, as SwyftCard hides behind the scenes until you need it.

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How SwyftCard Works

Leaping

SwyftCard allows you to move through text using two Leap keys: the open-apple and closed-apple keys on either side of the space bar. To make learning easy, a set of stick-on labels is provided to indicate which keys are used for special SwyftCard functions. Leaping means moving from one place in the text to another immediately.

Suppose the phrase *The number is less than the numerator* appears between the cursor and the end of the file and you want to locate the cursor on the *n* in *numerator*. Press the right Leap key as you type "n−u−m−e" to create a search pattern. After you have typed the "n," the cursor leaps to the next instance of *n* in the file, after the *u*, to the next instance of *nu*, and so on until it stops on the *n* in the word *numerator*.

If this isn't the instance of the word you want, press the Leap key, and the Leap Again key (Tab), to find the next occurrence of the letters. Leap Again auto-repeats; if you hold it down for more than half a second, the cursor will move rapidly from one instance of the pattern to the next. If the cursor arrives at the end of the file, it wraps back to the beginning. It will continue its forward direction until the Leap keys are released.

If you wish to leap to a point between the cursor and the beginning of the file, use the same procedure

with the left Leap key, and the search will take place in the reverse direction.

Lowercase letters in a leap pattern match both uppercase and lowercase letters in the text. Uppercase letters in the pattern match only uppercase in the text. You can leap from word to word (press Leap and the space bar), paragraph to paragraph (press Leap and Return), or page to page (press Leap and the Page key [Esc]).

Creeping

Moving the cursor over just a few characters is called creeping in the SwyftCard manual. To creep, press and release the right Leap key, and the cursor moves a character to the right. To creep in reverse, press the left Leap key.

Deleting

Deletes can also be done to the left or right of the cursor. While you are typing, if you press the Del key, the character to the left is erased as with the backspace key on a typewriter. After you leap or creep to a new place in the file, characters to the right of the cursor are deleted. The appearance of the cursor itself indicates which delete is operative. A narrow cursor is one character wide and appears when right delete is in effect; the wide cursor is two characters across with the cursor and the reverse-video character split.

Highlighting

Another useful SwyftCard feature is the highlighting of text. Highlighted text can be deleted, saved in a buffer for later insertion, printed, or telecommunicated. Highlighting takes place by pressing and releasing a Leap key, moving the cursor, and then pressing both Leap keys simultaneously. Any amount of text can be highlighted, from two characters to the entire document. Pressing Delete will remove all highlighted text from the screen and place it in a buffer. To restore the text, locate the cursor where you want the text and press Insert (Control-A). The deleted text remains in the buffer until you highlight and delete other text.

The Disk Command

You use the Disk key to read from or write a file to the disk. SwyftCard's method of handling disk files automatically takes care of whether reading or writing is required. Let's say you want to save some text. Put a floppy disk in the drive, and press the Disk key. SwyftCard notes if the disk is empty and that text is in RAM and deduces that a disk write is needed. When text has been saved, the cursor blinks rapidly to indicate that RAM and disk contents are identical.

On the other hand, if you are in the middle of writing and try to load a new file from a different floppy, SwyftCard will observe that some changes in RAM have not been saved and refuse to overwrite. A beep serves to remind you that the disk for the old file should be inserted in the drive to save changes. If you really do not want to save your changes, the procedure is to delete the text. These are examples of a well-planned user interface, designed to save the user from accidental, catastrophic errors, which all computer users have experienced at some time. Another example of this care is a SwyftCard com-

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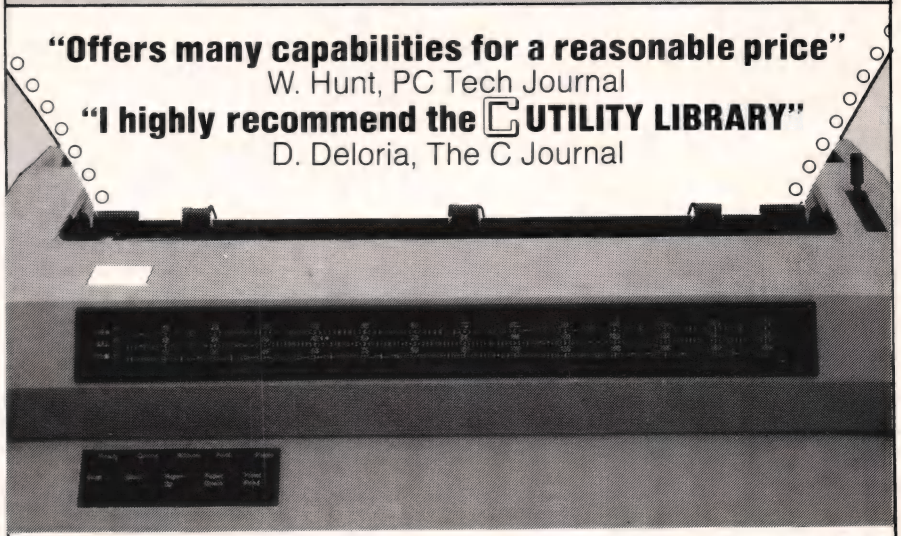

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SWYFTCARD
(continued from page 43)

mand that will make a disk look blank, in effect destroying anything on it and allowing you to write to it. Because this command can affect your data and is thus dangerous, it does not use the Disk key and is difficult to execute accidentally.

The Calc Command

The Calc command causes a BASIC statement to be executed in the file; for example, if you type "?34 + 78" and then highlight it and press the Calc key, the answer *112* will appear in place of the BASIC statement in your text. More complex executions are also possible. If you type

```
10 FOR I = 1 TO 31
20 PRINT "JANUARY"; I
30 NEXT I
RUN
```

then highlight this program and press the Calc key, the following calendar for January will be placed in your file where the program was:

```
JANUARY 1
JANUARY 2
JANUARY 3
    .
    .
JANUARY 30
JANUARY 31
```

Almost all BASIC commands will work, but the size of the BASIC program is limited to 900 bytes in the compacted internal form. Some uses of BASIC are dangerous—*CALL*, *PEEK*, and *POKE* can zap your file if used incorrectly or with values that interfere with the SwyftCard.

Awkward Moments

When the SwyftCard has used all available RAM memory, it will beep each time you press a key. To create room, execute at least two deletions. One is insufficient because the delete buffer continues to take up the same amount of RAM. At this point it is clearly advisable to save the file, insert a new disk, delete part of the text, and continue. This is one of the few awkward operations of SwyftCard. An improvement would be some sort of warning when all but 50 or 100 bytes of RAM had been used to allow for a more graceful conclusion of an editing session.

The SwyftCard approach of allowing each disk to hold one file is acceptable for a machine such as the Apple II, but as memory and hard disks continue to drop in price, the SwyftCard environment will have to adapt to machines with greater internal and external storage capabilities. These implementations will require a file management system and some scheme for mapping files into a range of RAM memory sizes.

These minor complaints are far less important than the many impressive characteristics of SwyftCard, including speed, ease of use, and diversity. Overall, SwyftCard offers a strikingly innovative user interface that deserves the attention of users and software developers interested in advancing the cause of usable computers.

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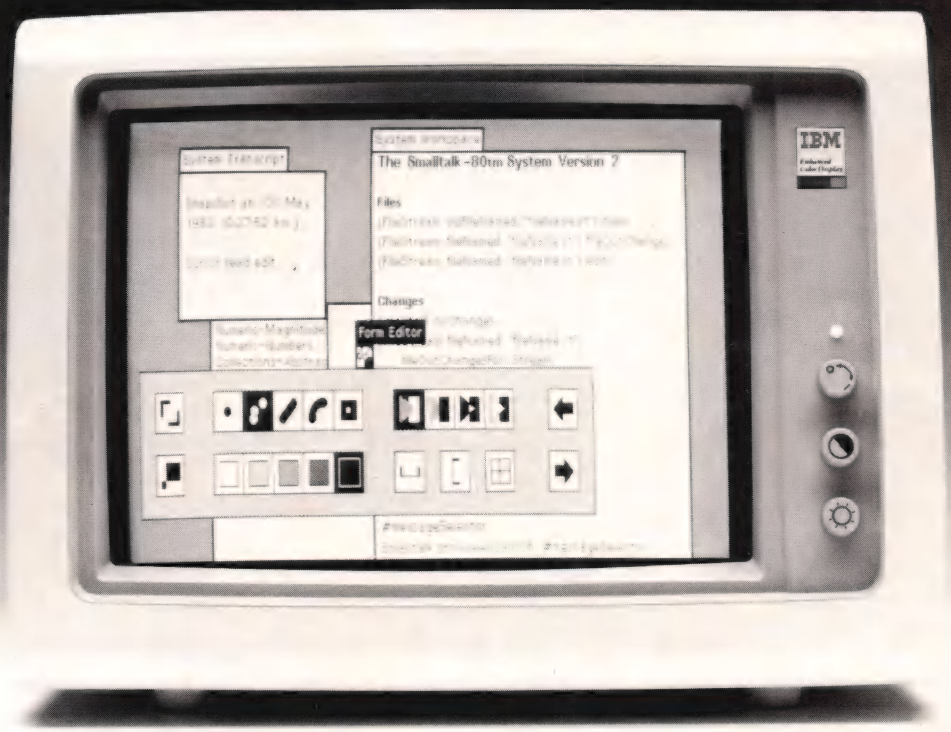

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Listing Seventeen (continued from May)

```
IMPLEMENTATION MODULE CodeGenerator;
(* Uses information supplied by Parser, OperationCodes, *)
(* and SyntaxAnalyzer to produce the object code.       *)

   FROM Strings IMPORT
      Length, CompareStr;

   FROM SymbolTable IMPORT
      FillSymTab, ReadSymTab;

   FROM Parser IMPORT
      TOKEN, OPERAND, OpLoc, SrcLoc, DestLoc;

   FROM LongNumbers IMPORT
      LONG, LongAdd, LongSub, LongInc, LongDec,
      LongClear, CardToLong, LongToCard, LongToInt,
      LongCompare, AddrBoundW, AddrBoundL;

   FROM OperationCodes IMPORT
      ModeTypeA, ModeTypeB, ModeA, ModeB, Instructions;

   FROM ErrorX68 IMPORT
      ErrorType, Error;

   FROM SyntaxAnalyzer IMPORT
      OpMode, Xtype, SizeType, OpConfig, Src, Dest,
      Size, Op, AddrModeA, AddrModeB, InstSize,
      GetValue, GetSize, GetInstModeSize, GetOperand, GetMultReg;


   CONST
      JMP = {14, 11, 10, 9, 7, 6};
      JSR = {14, 11, 10, 9, 7};
      RTE = {14, 11, 10, 9, 6, 5, 4, 1, 0};
      RTR = {14, 11, 10, 9, 6, 5, 4, 2, 1, 0};
      RTS = {14, 11, 10, 9, 6, 5, 4, 2, 0};
      TRAPV = {14, 11, 10, 9, 6, 5, 4, 2, 1};
      STOP = {14, 11, 10, 9, 6, 5, 4, 1};
      LINK = {14, 11, 10, 9, 6, 4};
      SWAP = {14, 11, 6};
      UNLK = {14, 11, 10, 9, 6, 4, 3};
      Quote = 47C;


   VAR
   (*---
      (* Defined in DEFINITION MODULE *)
      LZero, AddrCnt : LONG;
      Pass2 : BOOLEAN;
                                        ---*)
      AddrAdv : LONG;
      TempL : LONG;      (* Temporary variables *)
      TempI : INTEGER;
      TempC : CARDINAL;
      BrValue : LONG;    (* Used to calculate relative branches *)
      RevBr : BOOLEAN;


   PROCEDURE BuildSymTable (VAR AddrCnt : LONG;
                            Label, OpCode : TOKEN; SrcOp, DestOp : OPERAND);
   (* Builds symbol table from symbolic information of Source File *)

      VAR
         Value : LONG;
         Full : BOOLEAN;
         PseudoOp : BOOLEAN;

      BEGIN
         Value := LZero;
         AddrAdv := LZero;
         InstSize := 0;
         PseudoOp := FALSE;
         Size := S0;

         IF Length (OpCode) = 0 THEN
            RETURN;    (* Nothing added to symbol table, AddrCnt not changed *)
         END;

         GetSize (OpCode, Size);

         IF CompareStr (OpCode, "ORG") = 0 THEN
            GetValue (SrcOp, AddrCnt);
            AddrBoundW (AddrCnt);
            Value := AddrCnt;
            PseudoOp := TRUE;
         ELSIF CompareStr (OpCode, "EQU") = 0 THEN
            GetValue (SrcOp, Value);
            PseudoOp := TRUE;
         ELSIF CompareStr (OpCode, "DC") = 0 THEN
            CASE Size OF
               Word  :  AddrBoundW (AddrCnt);
            |  Long  :  AddrBoundL (AddrCnt);
            |  Byte  :  ;
            END;

            IF SrcOp[0] = Quote THEN    (* String Constant *)
               TempC := Length (SrcOp);
               IF TempC > 2 THEN
                  InstSize := TempC - 2;
               END;
            ELSE
               InstSize := ORD (Size);
            END;
            CardToLong (InstSize, AddrAdv);
            Value := AddrCnt;
            PseudoOp := TRUE;
         ELSIF CompareStr (OpCode, "DS") = 0 THEN
            GetValue (SrcOp, AddrAdv);
            Value := AddrCnt;
            PseudoOp := TRUE;
         ELSIF CompareStr (OpCode, "EVEN") = 0 THEN
            AddrBoundW (AddrCnt);
            Value := AddrCnt;
            PseudoOp := TRUE;
         ELSIF CompareStr (OpCode, "END") = 0 THEN
            PseudoOp := TRUE;
         ELSE
            Value := AddrCnt;
         END;

         IF Length (Label) # 0 THEN
            FillSymTab (Label, Value, Full);
            IF Full THEN
               Error (0, SymFull);
            END;
         END;

         IF NOT PseudoOp THEN

            Instructions (OpCode, OpLoc, Op, AddrModeA, AddrModeB);

            AddrBoundW (AddrCnt);
            Src.Loc := SrcLoc;   Dest.Loc := DestLoc;
            GetOperand (SrcOp, Src);
            GetOperand (DestOp, Dest);
            InstSize := 2;    (* minimum size of instruction *)

            IF Brnch IN AddrModeA THEN
               IF Size # Byte THEN
                  INC (InstSize, 2);
               END;
            ELSIF DecBr IN AddrModeA THEN
               INC (InstSize, 2);
            ELSE
               IF (Op = JMP) OR (Op = JSR) THEN    (* Allows for 'JMP.S' *)
                  IF (Size = Byte) AND (Src.Mode = AbsL) THEN
                     Src.Mode := AbsW;
                  END;
               END;

               TempC := GetInstModeSize (Src.Mode, Size, InstSize);
               TempC := GetInstModeSize (Dest.Mode, Size, InstSize);
            END;

            IF (Src.Mode = Imm) AND
              ((Data911 IN AddrModeA) OR (Data03 IN AddrModeA) OR
              (Data07 IN AddrModeA) OR (CntR911 IN AddrModeA)) THEN
               (* Quick instruction *)
               InstSize := 2;
            END;
            CardToLong (InstSize, AddrAdv);
         END;
      END BuildSymTable;


   PROCEDURE MergeModes (VAR SrcOp, DestOp : OPERAND;
                         VAR ObjOp, ObjSrc, ObjDest : LONG;
                         VAR nO,    nS,     nD      : CARDINAL);
   (*  Uses information from Instructions & GetOperand (among others)  *)
   (*  to complete calculation of Object Code.                          *)
   (*  Op, AddrModeA, AddrModeB, Size, and Src & Dest records are all   *)
   (*  Global variables imported from the SyntaxAnalyzer MODULE.        *)

      CONST
         (* BITSETs of the modes MISSING from effective address modes  *)
         aa = {};                  (* Effective addressing - all modes *)
         dea = {1};                (* Data effective addressing        *)
         mea = {1, 0};             (* Memory effective addressing      *)
         cea = {11, 4, 3, 1, 0};   (* Control effective addressing     *)
         aea = {11, 10, 9};        (* Alterable effective addressing   *)
         xxx = {15, 14, 13};       (* extra modes: CCR/SR/USP          *)
         (* 2 "AND" masks to turn off switch bits for shift/rotate *)
         Off910 = {15, 14, 13, 12, 11, 8, 7, 6, 5, 4, 3, 2, 1, 0};
         Off34 = {15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 2, 1, 0};

      VAR
         M : CARDINAL;
         i : CARDINAL;
         Ext : BITSET;       (* Bit pattern for instruction extension word *)
         ExtL : LONG;
         Xext : BITSET;
         Quick : BOOLEAN;


      PROCEDURE OperExt (VAR EA : OpConfig);
      (* Calculate Operand Extension word, and check range of Operands *)

         VAR
            GoodCard, GoodInt : BOOLEAN;

         BEGIN
            GoodCard := LongToCard (EA.Value, TempC);
            GoodInt := LongToInt (EA.Value, TempI);

            CASE EA.Mode OF
               AbsL     :  ;   (* No range checking needed *)
            |  AbsW     :  IF NOT GoodCard THEN
                              Error (EA.Loc, SizeErr);
                           END;
            |  ARDisp,
               PCDisp   :  IF NOT GoodInt THEN
                              Error (EA.Loc, SizeErr);
                           END;
            |  ARDisX,
               PCDisX   :  IF (TempI < -128) OR (TempI > 127) THEN
                              Error (EA.Loc, SizeErr);
                           END;
                           Xext := BITSET (EA.Xn * 4096);
                           IF EA.X = Areg THEN
                              Xext := Xext + {15};
                           END;
                           IF EA.Xsize = Long THEN
                              Xext := Xext + {11};
                           END;
                           CardToLong (CARDINAL (Xext), TempL);
                           EA.Value[3] := TempL[3];
                           EA.Value[4] := TempL[4];
            |  Imm      :  IF Size = Long THEN
                              (* No range check needed *)
                           ELSE
                              IF GoodInt THEN
                                 IF Size = Byte THEN
                                    IF (TempI < -128) OR (TempI > 127) THEN
                                       Error (EA.Loc, SizeErr);
                                    END;
                                 END;
                              ELSE
                                 Error (EA.Loc, SizeErr);
                              END;
                           END;
            ELSE
               (* No Action *)
            END;
         END OperExt;

      PROCEDURE EffAdr (VAR EA : OpConfig; Bad : BITSET);
      (* adds effective address field to Op (BITSET representing opcode) *)

         VAR
            M : CARDINAL;
            i : CARDINAL;
            Xext : BITSET;

         BEGIN
            M := ORD (EA.Mode);

            IF M IN Bad THEN
```

```
            Error (EA.Loc, ModeErr);
            RETURN;
         ELSIF M > 11 THEN
            RETURN;
         ELSIF M < 7 THEN
            Op := Op + BITSET (M * 8) + BITSET (EA.Rn);
         ELSE   (*    7  <=  M  <=  11    *)
            Op := Op + (5, 4, 3) + BITSET (M - 7);
         END;

         OperExt (EA);
      END EffAdr;

   BEGIN   (* MergeModes *)
      ExtL := LZero;
      Quick := FALSE;

      (* Check for 5 special cases first *)

      IF (Op = RTE) OR (Op = RTR) OR (Op = RTS) OR (Op = TRAPV) THEN
         IF Src.Mode # Null THEN
            Error (SrcLoc, OperErr);
         END;
      END;

      IF Op = STOP THEN
         IF (Src.Mode # Imm) OR (Dest.Mode # Null) THEN
            Error (SrcLoc, OperErr);
         END;
      END;

      IF Op = LINK THEN
         Op := Op + BITSET (Src.Rn);
         IF (Src.Mode # ARDir) OR (Dest.Mode # Imm) THEN
            Error (SrcLoc, ModeErr);
         END;
      END;

      IF Op = SWAP THEN
         IF EA05f IN AddrModeB THEN
            (* Ignore, this is PEA instruction! *)
         ELSE
            Op := Op + BITSET (Src.Rn);
            IF (Src.Mode # DReg) OR (Dest.Mode # Null) THEN
               Error (SrcLoc, OperErr);
            END;
         END;
      END;

      IF Op = UNLK THEN
         Op := Op + BITSET (Src.Rn);
         IF (Src.Mode # ARDir) OR (Dest.Mode # Null) THEN
            Error (SrcLoc, OperErr);
         END;
      END;

      (* Now do generalized address modes *)

      IF (Ry02 IN AddrModeA) AND (Rx911 IN AddrModeA) THEN
         Op := Op + BITSET (Src.Rn) + BITSET (Dest.Rn * 512);
         (* Now do some error checking! *)
         IF RegMem3 IN AddrModeA THEN
            IF Src.Mode = DReg THEN
               IF Dest.Mode # DReg THEN
                  Error (DestLoc, ModeErr);
               END;
            ELSIF Src.Mode = ARPre THEN
               Op := Op + {3};
               IF Dest.Mode # ARPre THEN
                  Error (DestLoc, ModeErr);
               END;
            ELSE
               Error (SrcLoc, OperErr);
            END;
         ELSE
            IF Src.Mode = ARPost THEN
               IF Dest.Mode # ARPost THEN
                  Error (DestLoc, ModeErr);
               END;
            ELSE
               Error (SrcLoc, OperErr);
            END;
         END;
      END;

      IF Data911 IN AddrModeA THEN
         Quick := TRUE;
         IF Src.Mode = Imm THEN
            IF LongToInt (Src.Value, TempI)
             AND (TempI > 0)
              AND (TempI <= 8) THEN
               IF TempI < 8 THEN   (* Data of 8 is coded as 000 *)
                  Op := Op + BITSET (TempI * 512);
               END;
            ELSE
               Error (SrcLoc, SizeErr);
            END;
         ELSE
            Error (SrcLoc, OperErr);
         END;
      END;

      IF CntR911 IN AddrModeA THEN
         (* Only Shift/Rotate use this *)
         IF Dest.Mode = DReg THEN
            Op := (Op * Off910) + BITSET (Dest.Rn);
            CASE Size OF
               Byte : ;
            |  Word : Op := Op + {6};
            |  Long : Op := Op + {7};
            END;
            IF Src.Mode = DReg THEN
               Op := Op + {5} + BITSET (Src.Rn * 512);
            ELSIF Src.Mode = Imm THEN
               Quick := TRUE;
               (* Range Check *)
               IF LongToInt (Src.Value, TempI)
                AND (TempI > 0)
                 AND (TempI <= 8) THEN
                  IF TempI < 8 THEN   (* Data of 8 is coded as 000 *)
                     Op := Op + BITSET (TempI * 512);
                  END;
               ELSE
                  Error (SrcLoc, SizeErr);
               END;
            ELSE
               Error (SrcLoc, OperErr);
            END;
         ELSIF Dest.Mode = Null THEN
```

(continued on next page)

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Listing Seventeen (listing continued)

```
      Op := (Op * Off34) + {7, 6};
      EffAdr (Src, (mea + aea));
   ELSE
      Error (SrcLoc, OperErr);
   END;
END;

IF Data03 IN AddrModeA THEN
   Quick := TRUE;
   IF Src.Mode = Imm THEN
      IF LongToInt (Src.Value, TempI)
       AND (TempI >= 0)
        AND (TempI < 16) THEN
         Op := Op + BITSET (TempI);
      ELSE
         Error (SrcLoc, SizeErr);
      END;
   ELSE
      Error (SrcLoc, OperErr);
   END;
END;

IF Data07 IN AddrModeA THEN
   Quick := TRUE;
   IF (Src.Mode = Imm) AND (Dest.Mode = DReg) THEN
      IF LongToInt (Src.Value, TempI)
       AND (TempI >= -128)
        AND (TempI <= 127) THEN
         Op := Op + (BITSET (TempI) * {7, 6, 5, 4, 3, 2, 1, 0})
                  + BITSET (Dest.Rn * 512);
      ELSE
         Error (SrcLoc, SizeErr);
      END;
   ELSE
      Error (SrcLoc, OperErr);
   END;
END;

IF OpM68D IN AddrModeA THEN
   IF Dest.Mode = DReg THEN
      Op := Op + BITSET (Dest.Rn * 512);
      IF (Src.Mode = ARDir) AND (Size = Byte) THEN
         Error (SrcLoc, SizeErr);
      END;
   ELSE   (* Assume Src.Mode = DReg -- Error trapped elsewhere *)
      Op := Op + BITSET (Src.Rn * 512);
      Op := Op + {8};
   END;

   CASE Size OF
      Byte : ;
   |  Word : Op := Op + {6};
   |  Long : Op := Op + {7};
   END;
END;

IF OpM68A IN AddrModeA THEN
   IF Dest.Mode = ARDir THEN
      Op := Op + BITSET (Dest.Rn * 512);
   ELSE
      Error (DestLoc, ModeErr);
   END;

   CASE Size OF
      Byte : Error (OpLoc, SizeErr);
   |  Word : Op := Op + {7, 6};
   |  Long : Op := Op + {8, 7, 6};
   END;
END;

IF OpM68C IN AddrModeA THEN
   IF Dest.Mode = DReg THEN
      Op := Op + BITSET (Dest.Rn * 512);
   ELSE
      Error (DestLoc, ModeErr);
   END;

   CASE Size OF
      Byte : IF Src.Mode = ARDir THEN
                Error (OpLoc, SizeErr);
             END;
   |  Word : Op := Op + {6};
   |  Long : Op := Op + {7};
   END;
END;

IF OpM68X IN AddrModeA THEN
   IF Src.Mode = DReg THEN
      Op := Op + BITSET (Src.Rn * 512);
   ELSE
      Error (SrcLoc, ModeErr);
   END;

   CASE Size OF
      Byte : Op := Op + {8};
   |  Word : Op := Op + {8, 6};
   |  Long : Op := Op + {8, 7};
   END;
END;

IF OpM68S IN AddrModeA THEN
   IF Src.Mode = DReg THEN
      Op := Op + BITSET (Src.Rn);
   ELSE
      Error (SrcLoc, ModeErr);
   END;

   CASE Size OF
      Byte : Error (OpLoc, SizeErr);
   |  Word : Op := Op + {7};
   |  Long :   Op := Op + {7, 6};
   END;
END;

IF OpM68R IN AddrModeA THEN
   IF (Src.Mode = DReg) AND (Dest.Mode = ARDisp) THEN
      CASE Size OF
         Byte : Error (OpLoc, SizeErr);
      |  Word : Op := Op + {8, 7};
      |  Long : Op := Op + {8, 7, 6};
      END;
      Op := Op + BITSET (Src.Rn * 512) + BITSET (Dest.Rn);
   ELSIF (Src.Mode = ARDisp) AND (Dest.Mode = DReg) THEN
      CASE Size OF
         Byte : Error (OpLoc, SizeErr);
      |  Word : Op := Op + {8};
      |  Long : Op := Op + {8, 6};
      END;
      Op := Op + BITSET (Src.Rn) + BITSET (Dest.Rn * 512);
   ELSE
      Error (SrcLoc, ModeErr);
   END;
END;

IF OpM37 IN AddrModeA THEN
   IF (Src.Mode = DReg) AND (Dest.Mode = DReg) THEN
      Op := Op + {6} + BITSET (Src.Rn * 512) + BITSET (Dest.Rn);
   ELSIF (Src.Mode = ARDir) AND (Dest.Mode = ARDir) THEN
      Op := Op + {6, 3} + BITSET (Src.Rn * 512) + BITSET (Dest.Rn);
   ELSIF (Src.Mode = ARDir) AND (Dest.Mode = DReg) THEN
      Op := Op + {7, 3} + BITSET (Dest.Rn * 512) + BITSET (Src.Rn);
   ELSIF (Src.Mode = DReg) AND (Dest.Mode = ARDir) THEN
      Op := Op + {7, 3} + BITSET (Src.Rn * 512) + BITSET (Dest.Rn);
   ELSE
      Error (SrcLoc, ModeErr);
   END;
END;

IF Bit811 IN AddrModeB THEN
   IF Src.Mode = DReg THEN
      Op := Op + {8} + BITSET (Src.Rn * 512);
   ELSIF Src.Mode = Imm THEN
      Op := Op + {11};
   ELSE
      Error (SrcLoc, ModeErr);
   END;
END;

IF Size67 IN AddrModeB THEN
   CASE Size OF
      Byte : ;(* No action -- bits already 0's *)
   |  Word : Op := Op + {6};
   |  Long : Op := Op + {7};
   END;
END;

IF Size6 IN AddrModeB THEN
   CASE Size OF
      Byte : Error (OpLoc, SizeErr);
   |  Word : (* No Action -- BIT is already 0 *)
   |  Long : Op := Op + {6};
   END;
END;

IF Size1213A IN AddrModeB THEN
   CASE Size OF
      Byte : Op := Op + {12};
   |  Word : Op := Op + {13, 12};
   |  Long : Op := Op + {13};
   END;
END;

IF Size1213 IN AddrModeB THEN
   Op := Op + BITSET (Dest.Rn * 512);
   CASE Size OF
      Byte : Error (OpLoc, SizeErr);
   |  Word : Op := Op + {13, 12};
   |  Long : Op := Op + {13};
   END;
END;

IF EA05a IN AddrModeB THEN
   IF (Dest.Mode = DReg) OR (Dest.Mode = ARDir) THEN
      EffAdr (Src, ea);
   ELSE
      Error (DestLoc, ModeErr);
   END;
END;

IF EA05b IN AddrModeB THEN
   IF Dest.Mode = DReg THEN
      EffAdr (Src, dea);
      Op := Op + BITSET (Dest.Rn * 512);
   ELSE
      Error (DestLoc, ModeErr);
   END;
END;

IF EA05c IN AddrModeB THEN
   EffAdr (Dest, {11, 1});
END;

IF EA05d IN AddrModeB THEN
   EffAdr (Dest, aea);
   IF (Dest.Mode = ARDir) AND (Size = Byte) THEN
      Error (OpLoc, SizeErr);
   END;
END;

IF EA05e IN AddrModeB THEN
   IF Dest.Mode = Null THEN
      EffAdr (Src, (dea + aea));
   ELSIF (Src.Mode = Imm) OR (Src.Mode = DReg) THEN
      EffAdr (Dest, (dea + aea));
   ELSE
      Error (SrcLoc, ModeErr);
   END;
END;

IF EA05f IN AddrModeB THEN    (* LEA & PEA / JMP & JSR *)
   EffAdr (Src, cea);
   IF Rx911 IN AddrModeA THEN
      IF Dest.Mode = ARDir THEN
         Op := Op + BITSET (Dest.Rn * 512);
      ELSE
         Error (DestLoc, ModeErr);
      END;
   ELSE
      IF Dest.Mode # Null THEN
         Error (DestLoc, OperErr);
      END;
   END;
END;

IF EA05x IN AddrModeB THEN
   IF Dest.Mode = DReg THEN
      EffAdr (Src, dea);
   ELSIF Src.Mode = DReg THEN
      EffAdr (Dest, mea + aea);
   ELSE
      Error (SrcLoc, OperErr);
   END;
END;

IF EA05y IN AddrModeB THEN
   IF Dest.Mode = DReg THEN
      EffAdr (Src, ea);
      IF (Src.Mode = ARDir) AND (Size = Byte) THEN
```

(continued on page 50)

WIZARD C

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The following SIEVE benchmark was run without register variable declarations on an IBM/PC with 640K memory and an 8087.

	Exec Time	Code Size	EXE Size
Wizard C 3.0	**: 6.8**	**130**	**7,766**
Microsoft	:11.5	186	7,018
Lattice	:11.8	164	20,068

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Listing Seventeen (listing continued)

```
            Error (OpLoc, SizeErr);
         END;
      ELSIF Src.Mode = DReg THEN
         EffAdr (Dest, (mea + aea));
      ELSE
         Error (SrcLoc, ModeErr);
      END;
   END;

   IF EA05z IN AddrModeB THEN
      IF Src.Mode = MultiM THEN
         EffAdr (Dest, (mea + aea + {3}));
         GetMultReg (SrcOp, (Dest.Mode = ARPre), SrcLoc, Ext);
      ELSIF Dest.Mode = MultiM THEN
         EffAdr (Src, (mea + {11, 4}));
         GetMultReg (DestOp, (Src.Mode = ARPre), DestLoc, Ext);
         Op := Op + {10};   (* set direction *)
      ELSE
         Error (SrcLoc, OperErr);
      END;

      INC (nO, 4);   (* extension is part of OpCode *)
      INC (InstSize, 2);
      CardToLong (CARDINAL (Ext), ExtL);
   END;

   IF EA611 IN AddrModeB THEN
      IF Dest.Mode = CCR THEN
         Op := {14, 10, 7, 6};
         EffAdr (Src, dea);
      ELSIF Dest.Mode = SR THEN
         Op := {14, 10, 9, 7, 6};
         EffAdr (Src, dea);
      ELSIF Src.Mode = SR THEN
         Op := {14, 7, 6};
         EffAdr (Dest, dea + aea);
      ELSIF Dest.Mode = USP THEN
         Op := {14, 11, 10, 9, 6, 5};
         IF Src.Mode = ARDir THEN
            Op := Op + BITSET (Src.Rn);
         ELSE
            Error (SrcLoc, ModeErr);
         END;
      ELSIF Src.Mode = USP THEN
         Op := {14, 11, 10, 9, 6, 5, 3};
         IF Dest.Mode = ARDir THEN
            Op := Op + BITSET (Dest.Rn);
         ELSE
            Error (DestLoc, ModeErr);
         END;
      ELSE
         EffAdr (Src, (ea + xxx));
         IF (Size = Byte) AND (Src.Mode = ARDir) THEN
            Error (SrcLoc, SizeErr);
         END;

         M := ORD (Dest.Mode);
         IF (M IN (dea + aea)) OR (M > 11) THEN
            Error (DestLoc, ModeErr);
         ELSIF M < 7 THEN
            Op := Op + BITSET (M * 64) + BITSET (Dest.Rn * 512);
         ELSE   (* 7 <= M <= 11 *)
            Op := Op + {8, 7, 6} + BITSET ((M - 7) * 512);
         END;

         OperExt (Dest);
      END;
   END;

   IF (Dest.Mode = CCR) AND (Src.Mode = Imm) THEN
      IF (Size67 IN AddrModeB)
       AND (EA05e IN AddrModeB)
        AND (Exten IN AddrModeB) THEN
         IF 10 IN Op THEN   (* NOT ANDI/EORI/ORI *)
            Error (DestLoc, ModeErr);
         ELSE
            Op := Op * {15, 14, 13, 12, 11, 10, 9, 8};   (* AND mask *)
            Op := Op + {5, 4, 3, 2};                     (*  OR mask *)
         END;
      END;
   END;

   IF (Dest.Mode = SR) AND (Src.Mode = Imm) THEN
      IF (Size67 IN AddrModeB)
       AND (EA05e IN AddrModeB)
        AND (Exten IN AddrModeB) THEN
         IF 10 IN Op THEN   (* NOT ANDI/EORI/ORI *)
            Error (DestLoc, ModeErr);
         ELSE
            Op := Op * {15, 14, 13, 12, 11, 10, 9, 8};   (* AND mask *)
            Op := Op + {6, 5, 4, 3, 2};                  (*  OR mask *)
         END;
      END;
   END;

   CardToLong (CARDINAL (Op), ObjOp);
   INC (InstSize, 2);
   INC (nO, 4);
   IF nO > 4 THEN
      FOR i := 1 TO 4 DO   (* move ObjOp -- make room for extension *)
         ObjOp[i + 4] := ObjOp[i];
         ObjOp[i] := ExtL[i];
      END;
   END;

   nS := GetInstModeSize (Src.Mode, Size, InstSize);
   ObjSrc := Src.Value;
   nD := GetInstModeSize (Dest.Mode, Size, InstSize);
   ObjDest := Dest.Value;

   IF Quick THEN
      InstSize := 2;
      nS := 0;   nD := 0;
   END;
   CardToLong (InstSize, AddrAdv);

END MergeModes;


TYPE
   DirType = (None, Org, Equ, DC, DS, Even, End);

PROCEDURE ObjDir (OpCode : TOKEN; SrcOp : OPERAND; Size : SizeType;
                  VAR AddrCnt, ObjOp, ObjSrc, ObjDest : LONG;
                  VAR   nA,      nO,     nS,      nD     : CARDINAL) : DirType;
(* Generates Object Code for Assembler Directives *)

   VAR
      Dir : DirType;
      i, j : CARDINAL;
      LongString : ARRAY [1..20] OF INTEGER;

   BEGIN
      AddrAdv := LZero;

      IF CompareStr (OpCode, "ORG") = 0 THEN
         GetValue (SrcOp, AddrCnt);
         AddrBoundW (AddrCnt);
         Dir := Org;
      ELSIF CompareStr (OpCode, "EQU") = 0 THEN
         GetValue (SrcOp, ObjSrc);
         nS := 8;
         Dir := Equ;
      ELSIF CompareStr (OpCode, "DC") = 0 THEN
         CASE Size OF
            Word  :  AddrBoundW (AddrCnt);
          | Long  :  AddrBoundL (AddrCnt);
          | Byte  :  ;
         END;

         IF SrcOp[0] = Quote THEN   (* String constant *)
            TempC := Length (SrcOp);
            IF TempC > 2 THEN
               InstSize := TempC - 2;   (* Don't count the Quotes *)
            END;

            i := 1;   j := 20;
            WHILE i <= InstSize DO   (* Change from ASCII to LONG *)
               CardToLong (ORD (SrcOp[i]), TempL);
               LongString[j] := TempL[2];
               LongString[j - 1] := TempL[1];
               INC (i);   DEC (j, 2);
            END;

            i := 1;   INC (j);
            WHILE j <= 20 DO   (* Left Justify String *)
               LongString[i] := LongString[j];
               INC (i);   INC (j);
            END;

            DEC (i);
            WHILE i > 16 DO   (* Transfer 2 bytes to OpCode *)
               ObjOp[i - 16] := LongString[i];
               INC (nO);   DEC (i);
            END;

            WHILE i > 8 DO   (* Transfer 4 bytes to Source Operand *)
               ObjSrc[i - 8] := LongString[i];
               INC (nS);   DEC (i);
            END;

            WHILE i > 0 DO   (* Transfer 4 bytes to Destination Operand *)
               ObjDest[i] := LongString[i];
               INC (nD);   DEC (i);
            END;

            IF SrcOp[InstSize + 1] # Quote THEN
               Error ((SrcLoc + InstSize + 1), OperErr);
            END;
         ELSE   (* not a string constant *)
            GetValue (SrcOp, ObjSrc);
            InstSize := ORD (Size);
            nS := InstSize * 2;
         END;
         CardToLong (InstSize, AddrAdv);
         nA := 6;
         Dir := DC;
      ELSIF CompareStr (OpCode, "DS") = 0 THEN
         GetValue (SrcOp, AddrAdv);
         nA := 6;   nS := 2;   ObjSrc := LZero;
         Dir := DS;
      ELSIF CompareStr (OpCode, "EVEN") = 0 THEN
         AddrBoundW (AddrCnt);
         Dir := Even;
      ELSIF CompareStr (OpCode, "END") = 0 THEN
         nA := 6;
         Dir := End;
      ELSE
         Dir := None;
      END;

      RETURN (Dir);
   END ObjDir;


PROCEDURE AdvAddrCnt (VAR AddrCnt : LONG);
(* Advances the address counter based on the length of the instruction *)
   BEGIN
      LongAdd (AddrCnt, AddrAdv, AddrCnt);
   END AdvAddrCnt;


PROCEDURE GetObjectCode (Label, OpCode : TOKEN;
                         SrcOp, DestOp : OPERAND;
                         VAR AddrCnt, ObjOp, ObjSrc, ObjDest : LONG;
                         VAR   nA,      nO,     nS,      nD     : CARDINAL);
(* Determines the object code for the operation as well as the operands *)
(* Returns each (up to 3 fields), along with the length of each.       *)

   VAR
      Dummy : BOOLEAN;
      Dir : DirType;

   BEGIN
      AddrAdv := LZero;
      InstSize := 0;
      nA := 0;   nO := 0;   nS := 0;   nD := 0;

      IF Length (OpCode) = 0 THEN
         (* ensure no code generated *)
         RETURN;
      END;

      GetSize (OpCode, Size);

      Dir := ObjDir (OpCode, SrcOp, Size,
                     AddrCnt, ObjOp, ObjSrc, ObjDest,
                       nA,      nO,     nS,      nD     );

      IF (Length (Label) # 0) AND (Dir # Equ) THEN
      (* Check for phase error *)
         Dummy := ReadSymTab (Label, TempL, Dummy);
         IF LongCompare (TempL, AddrCnt) # 0 THEN
            Error (0, Phase);
         END;
```

(continued on page 52)

SAS Institute Inc. Announces

Lattice C Compilers for Your IBM Mainframe

Two years ago...

SAS Institute launched an effort to develop a subset of the SAS® Software System for the IBM Personal Computer. After careful study, we agreed that C was the programming language of choice. And that the Lattice® C compiler offered the quality, speed, and efficiency we needed.

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- **Generated code executable in both 24-bit and 31-bit addressing modes.** You can run compiled programs above the 16 megabyte line in MVS/XA.
- **Generated code identical for OS and CMS operating systems.** You can move modules between MVS and CMS without even recompiling.
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- **Built-in functions.** Many of the traditional string handling functions are available as built-in functions, generating in-line machine code rather than function calls. Your call to move a string can result in just one MVC instruction rather than a function call and a loop.

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Listing Seventeen (listing continued)

```
        END;

        IF Dir = None THEN    (* Instruction *)
           AddrBoundW (AddrCnt);
        ELSE
           RETURN;
        END;

        Instructions (OpCode, OpLoc, Op, AddrModeA, AddrModeB);
        Src.Loc := SrcLoc;   Dest.Loc := DestLoc;
        GetOperand (SrcOp, Src);    (* Src & Dest are RECORDS *)
        GetOperand (DestOp, Dest);

        IF DecBr IN AddrModeA THEN    (* Decrement & Branch *)
           IF Src.Mode # DReg THEN
              Error (SrcLoc, ModeErr);
           END;

           BrValue := Dest.Value;
           TempL := AddrCnt;
           TempC := 32767;    (* Maximum Branch *)
           LongInc (TempL, 2);    (* move past instruction for Rel Adr Calc *)

           IF LongCompare (BrValue, TempL) < 0 THEN
              RevBr := TRUE;
              LongSub (TempL, BrValue, BrValue);
              INC (TempC);    (* can branch 1 farther in reverse *)
           ELSE
              RevBr := FALSE;
              LongSub (BrValue, TempL, BrValue);
           END;

           CardToLong (TempC, TempL);    (* Maximum Branch distance *)

           IF LongCompare (BrValue, TempL) > 0 THEN
              Error (DestLoc, BraErr);
           END;
           IF RevBr THEN    (* Make Negative *)
              LongSub (LZero, BrValue, BrValue)
           END;

           CardToLong (4, AddrAdv);
           nA := 6;    nO := 4;    nS := 4;
           CardToLong (CARDINAL (Op + BITSET (Src.Rn)), ObjOp);
           ObjSrc := BrValue;
           RETURN;
        END;

        IF Brnch IN AddrModeA THEN    (* Branch *)
           BrValue := Src.Value;    (* Destination of Branch *)
           TempL := AddrCnt;
           LongInc (TempL, 2);

           IF Size # Byte THEN    (* Byte Size ---> Short Branch *)
              TempC := 32767;    (* Set maximum branch distance *)
           ELSE
              TempC := 127;
           END;

           CASE LongCompare (BrValue, TempL) OF
              -1 :  (* Reverse Branch *)
                    RevBr := TRUE;
                    INC (TempC);    (* can branch 1 farther in reverse *)
                    LongSub (TempL, BrValue, BrValue);
           |  +1 :  (* Forward Branch *)
                    RevBr := FALSE;
                    LongSub (BrValue, TempL, BrValue);
           |   0 :  IF Size = Byte THEN
                       Error (SrcLoc, BraErr);
                    END;
           END;

           CardToLong (TempC, TempL);

           IF LongCompare (BrValue, TempL) > 0 THEN
              Error (SrcLoc, BraErr);
           END;

           IF RevBr THEN
              LongSub (LZero, BrValue, BrValue);    (* Make negative *)
           END;

           IF Size # Byte THEN
              InstSize := 4;
              nS := 4;
              ObjSrc := BrValue;
           ELSE
              InstSize := 2;
              Dummy := LongToInt (BrValue, TempI);
              Op := Op + (BITSET (TempI) * {7, 6, 5, 4, 3, 2, 1, 0});
           END;

           nA := 6;    nO := 4;
           CardToLong (InstSize, AddrAdv);
           CardToLong (CARDINAL (Op), ObjOp);
           RETURN;
        END;

        nA := 6;
        IF (Op = JMP) OR (Op = JSR) THEN    (* Allows for 'JMP.S' *)
           IF (Size = Byte) AND (Src.Mode = AbsL) THEN
              Src.Mode := AbsW;
           END;
        END;
        MergeModes (SrcOp, DestOp, ObjOp, ObjSrc, ObjDest, nO, nS, nD);

     END GetObjectCode;


BEGIN    (* MODULE Initialization *)
   LongClear (LZero);    (* Used as a constant *)
   AddrCnt := LZero;
   Pass2 := FALSE;
END CodeGenerator.
```

End Listing Seventeen

Listing Eighteen

```
IMPLEMENTATION MODULE SyntaxAnalyzer;
(* Analyzes the operands to provide information for CodeGenerator *)

   FROM Conversions IMPORT
      StrToCard;

   FROM Strings IMPORT
      Length;

   FROM LongNumbers IMPORT
      LONG, LongAdd, LongSub, CardToLong, StringToLong;

   FROM SymbolTable IMPORT
      SortSymTab, ReadSymTab;

   FROM ErrorX68 IMPORT
      ErrorType, Error;

   FROM Parser IMPORT
      OPERAND, SrcLoc;

   FROM CodeGenerator IMPORT
      LZero, AddrCnt, Pass2;    (* BOOLEAN Switch *)


   CONST
      Zero = 30H;    (* The Ordinal value of the Character '0' *)
      Seven = 37H;    (* The Ordinal value of the Character '7' *)
      Quote = 47C;

(*---
   TYPE
      OpMode = (DReg,       (* Data Register *)
                ARDir,      (* Address Register Direct *)
                ARInd,      (* Address Register Indirect *)
                ARPost,     (* Address Register with Post-Increment *)
                ARPre,      (* Address Register with Pre-Decrement *)
                ARDisp,     (* Address Register with Displacement *)
                ARDisX,     (* Address Register with Disp. & Index *)
                AbsW,       (* Absolute Word (16-bit Address) *)
                AbsL,       (* Absolute Word (32-bit Address) *)
                PCDisp,     (* Program Counter Relative, with Displacement *)
                PCDisX,     (* Program Counter Relative, with Disp. & Index *)
                Imm,        (* Immediate *)
                MultiM,     (* Multiple Register Move *)
                SR,         (* Status Register *)
                CCR,        (* Condition Code Register *)
                USP,        (* User's Stack Pointer *)
                Null);      (* Error Condition, or Operand missing *)

      Xtype = (X0, Dreg, Areg);
      SizeType = (S0, Byte, Word, S3, Long);

      OpConfig = RECORD                    (* OPERAND CONFIGURATION *)
                    Mode : OpMode;
                    Value : LONG;
                    Loc : CARDINAL;        (* Location of Operand on line *)
                    Rn : CARDINAL;         (* Register number *)
                    Xn : CARDINAL;         (* Index Reg. nbr. *)
                    Xsize : SizeType;      (* size of Index *)
                    X : Xtype;             (* Is index Data or Address reg? *)
                 END;


   VAR
      Size : SizeType;        (* size for OpCode *)
      AbsSize : SizeType;     (* size of operand (Absolute only) *)
      InstSize : CARDINAL;    (* Size of instruction, including operands *)
      AddrModeA : ModeA;      (* Addressing modes for this instruction *)
      AddrModeB : ModeB;      (*                ditto                  *)
      Op : BITSET;            (* Raw bit pattern for OpCode *)
      Src, Dest : OpConfig;
                                                                    ---*)


   PROCEDURE CalcValue (Operand : OPERAND; VAR Value : LONG);
   (* Calculates left and right values for GetValue *)

      VAR
         Full : BOOLEAN;
         Neg : BOOLEAN;
         Dup : BOOLEAN;
         Num : CARDINAL;
         NumSyms : CARDINAL;

      BEGIN
         IF Operand[0] = '-' THEN
            Neg := TRUE;
            Operand[0] := '0';
         ELSE
            Neg := FALSE;
         END;

         IF StrToCard (Operand, Num) THEN
            (* It is a number *)
            CardToLong (Num, Value);
            IF Neg THEN
               LongSub (LZero, Value, Value);
            END;
         ELSIF StringToLong (Operand, Value) THEN
            (* It is a HEX number *)
         ELSIF (Operand[0] = Quote) AND (Operand[2] = Quote) THEN
            CardToLong (ORD (Operand[1]), Value);
         ELSIF (Length (Operand) = 1) AND (Operand[0] = '*') THEN
            Value := AddrCnt;
         ELSE
            (* It is a label, but may be undefined! *)
            IF NOT Pass2 THEN
               SortSymTab (NumSyms);
            END;
            IF NOT ReadSymTab (Operand, Value, Dup) THEN
               Error (SrcLoc, Undef);
            END;
            IF Dup THEN
               Error (SrcLoc, SymDup);
            END;
         END;
      END CalcValue;


   PROCEDURE GetValue (Operand : OPERAND; VAR Value : LONG);
   (* determines value of operand (in Decimal, HEX, or via Symbol Table) *)

      VAR
         TempOp : OPERAND;
         TempVal : LONG;
         c, op : CHAR;
         i, j : CARDINAL;

         InQuotes : BOOLEAN;
```

(continued on page 54)

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Listing Eighteen (listing continued)

```
    BEGIN
       i := 0;
       Value := LZero;
       InQuotes := FALSE;
       op := '+';
       REPEAT
          j := 0;
          LOOP
             c := Operand[i];
             TempOp[j] := c;
             IF c = Quote THEN
                InQuotes := NOT InQuotes;
             END;
             INC (i);   INC (j);
             IF c = 0C THEN
                EXIT;
             END;
             IF (c = '+') AND (NOT InQuotes) THEN
                EXIT;
             END;
             IF (c = '-') AND (i > 1) AND (NOT InQuotes) THEN
                EXIT;
             END;
          END;
          TempOp[j - 1] := 0C;   (* in case c is +/- *)
          CalcValue (TempOp, TempVal);
          IF op = '-' THEN
             LongSub (Value, TempVal, Value);
          ELSE
             LongAdd (Value, TempVal, Value);
          END;
          op := c;
       UNTIL op = 0C;
    END GetValue;


PROCEDURE GetSize (VAR Symbol : ARRAY OF CHAR; VAR Size : SizeType);
(* determines size of opcode/operand: Byte, Word, Long *)

    VAR
       i : CARDINAL;
       c : CHAR;

    BEGIN
       i := 0;
       REPEAT
          c := Symbol[i];
          INC (i);
       UNTIL (c = 0C) OR (c = '.');

       IF c = 0C THEN
          Size := Word;   (* Default to size Word = 16 bits *)
       ELSE
          c := Symbol[i];   (* Record size extension *)
          Symbol[i - 1] := 0C;   (* Chop size extension off *)
          IF (c = 'B') OR (c = 'S') THEN   (* Byte or Short Branch/Jump *)
             Size := Byte;
          ELSIF c = 'L' THEN
             Size := Long;
          ELSE
             Size := Word;   (* Default size *)
          END;
       END;
    END GetSize;


PROCEDURE GetAbsSize (VAR Symbol : ARRAY OF CHAR; VAR AbsSize : SizeType);
(* determines size of operand: Word or Long *)

    VAR
       i : CARDINAL;
       c : CHAR;
       ParCnt : INTEGER;

    BEGIN
       ParCnt := 0;
       i := 0;
       REPEAT
          c := Symbol[i];
          IF c = '(' THEN
             INC (ParCnt);
          END;
          IF c = ')' THEN
             DEC (ParCnt);
          END;
          INC (i);
       UNTIL (c = 0C) OR ((c = '.') AND (ParCnt = 0));

       IF c = 0C THEN
          AbsSize := Long;
       ELSE
          c := Symbol[i];   (* Record size extension *)
          Symbol[i - 1] := 0C;   (* Chop size extension off *)
          IF (c = 'W') OR (c = 'S') THEN
             AbsSize := Word;
          ELSE
             AbsSize := Long;
          END;
       END;
    END GetAbsSize;



PROCEDURE GetInstModeSize (Mode : OpMode; Size : SizeType;
                           VAR InstSize : CARDINAL) : CARDINAL;
(* Determines the size for the various instruction modes.     *)

    VAR
       n : CARDINAL;

    BEGIN
       CASE Mode OF
          ARDisp,
          ARDisX,
          PCDisp,
          PCDisX,
          AbsW     :  n := 2;
        | AbsL     :  n := 4;
        | MultiM   :  IF Pass2 THEN
                         n := 0;   (* accounted for by code generator *)
                      ELSE
                         n := 2;
                      END;
        | Imm      :  IF Size = Long THEN
                         n := 4;
                      ELSE
                         n := 2;
                      END;
       ELSE
                      n := 0;
       END;

       INC (InstSize, n);
       RETURN (n * 2);
    END GetInstModeSize;


PROCEDURE GetOperand (Oper : OPERAND; VAR Op : OpConfig);
(* Finds mode and value for source or destination operand *)

    VAR
       ch : CHAR;
       C : CARDINAL;   (* holds the ordinal value of a charcter *)
       i, j : CARDINAL;
       Len : CARDINAL;   (* Calculated Length of Oper *)
       TempOp : OPERAND;
       MultFlag : BOOLEAN;

    BEGIN
       Op.Mode := Null;   Op.X := X0;
       Len := Length (Oper);

       IF Len = 0 THEN
          RETURN;
       END;

       GetAbsSize (Oper, AbsSize);

       IF Oper[0] = '#' THEN   (* Immediate *)
          IF Pass2 THEN
             i := 0;
             REPEAT
                INC (i);
                Oper[i - 1] := Oper[i];
             UNTIL Oper[i] = 0C;
             GetValue (Oper, Op.Value);
          END;
          Op.Mode := Imm;
          RETURN;
       END;

       IF Len = 2 THEN   (* possible Addr or Data Register *)
          C := ORD (Oper[1]);
          IF (Oper[0] = 'S') AND (Oper[1] = 'R') THEN
             (* Status Register *)
             Op.Mode := SR;
             RETURN;
          ELSIF (Oper[0] = 'S') AND (Oper[1] = 'P') THEN
             (* Stack Pointer *)
             Op.Mode := ARDir;
             Op.Rn := 7;
             RETURN;
          ELSIF (C >= Zero) AND (C <= Seven) THEN
             (* Looks Like an Addr or Data Reg *)
             IF Oper[0] = 'A' THEN   (* Address Register *)
                Op.Mode := ARDir;
                Op.Rn := C - Zero;
                RETURN;
             ELSIF Oper[0] = 'D' THEN   (* Data Register *)
                Op.Mode := DReg;
                Op.Rn := C - Zero;
                RETURN;
             ELSE
                (* may be a label -- ignore for now *)
             END;
          ELSE
             (* may be a label -- ignore for now *)
          END;
       END;

       IF Len = 3 THEN
          IF (Oper[0] = 'C') AND (Oper[1] = 'C') AND (Oper[2] = 'R') THEN
             (* Condition Code Register *)
             Op.Mode := CCR;
             RETURN;
          ELSIF (Oper[0] = 'U') AND (Oper[1] = 'S') AND (Oper[2] = 'P') THEN
             (* User's Stack Pointer *)
             Op.Mode := USP;
             RETURN;
          ELSE
             (* may be a label -- ignore for now *)
          END;
       END;

       IF (Len = 4) AND (Oper[0] = '(') AND (Oper[3] = ')') THEN
          IF (Oper[1] = 'S') AND (Oper[2] = 'P') THEN
             Op.Mode := ARInd;
             Op.Rn := 7;
             RETURN;
          ELSIF Oper[1] = 'A' THEN
             C := ORD (Oper[2]);
             IF (C >= Zero) AND (C <= Seven) THEN
                Op.Mode := ARInd;
                Op.Rn := C - Zero;
                RETURN;
             ELSE
                Error (Op.Loc, SizeErr);
                RETURN;
             END;
          ELSE
             Error (Op.Loc, AddrErr);
             RETURN;
          END;
       END;

       IF (Len = 5) AND (Oper[0] = '(')
        AND (Oper[3] = ')') AND (Oper[4] = '+') THEN
         (* Address Indirect with Post Inc *)
          IF (Oper[1] = 'S') AND (Oper[2] = 'P') THEN
             (* System Stack Pointer *)
             Op.Mode := ARPost;
             Op.Rn := 7;
             RETURN
          ELSIF Oper[1] = 'A' THEN
             C := ORD (Oper[2]);
             IF (C >= Zero) AND (C <= Seven) THEN
                Op.Mode := ARPost;
                Op.Rn := C - Zero;
                RETURN;
             ELSE
                Error (Op.Loc, SizeErr);
                RETURN;
             END;
```

(continued on page 56)

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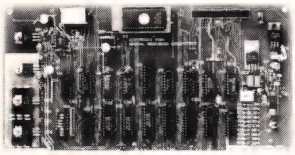

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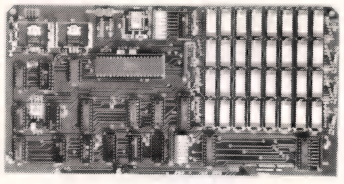

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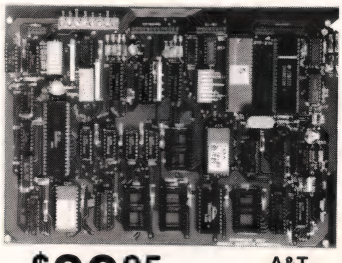

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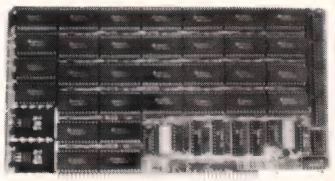

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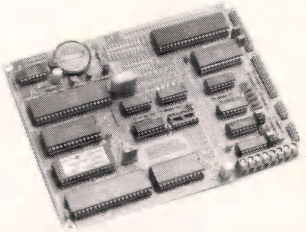

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Listing Eighteen (listing continued)

```
      ELSE
         Error (Op.Loc, AddrErr);
         RETURN;
      END;
   END;

   IF (Len = 5) AND (Oper[0] = '-')
    AND (Oper[1] = '(') AND (Oper[4] = ')') THEN
      IF (Oper[2] = 'S') AND (Oper[3] = 'P') THEN
         (* System Stack Pointer *)
         Op.Mode := ARPre;
         Op.Rn := 7;
         RETURN;
      ELSIF Oper[2] = 'A' THEN
         C := ORD (Oper[3]);
         IF (C >= Zero) AND (C <= Seven) THEN
            Op.Mode := ARPre;
            Op.Rn := C - Zero;
            RETURN;
         ELSE
            Error (Op.Loc, SizeErr);
            RETURN;
         END;
      ELSE
         Error (Op.Loc, AddrErr);
         RETURN;
      END;
   END;

   (* Try to split off displacement (if present) *)
   i := 0;
   ch := Oper[i];
   WHILE (ch # '(') AND (ch # 0C) DO    (* move to TempOp *)
      TempOp[i] := ch;
      INC (i);
      ch := Oper[i];
   END;
   TempOp[i] := 0C;    (* Displacement (it it exists) now in TempOp *)

   IF ch = '(' THEN    (* looks like a displacement mode *)
      IF Pass2 THEN
         GetValue (TempOp, Op.Value);    (* Value of Disp. *)
      END;
      j := 0;
      REPEAT    (* put rest of operand (eg. (An,Xi) in TempOp *)
         ch := Oper[i];
         TempOp[j] := ch;
         INC (i);    INC (j);
      UNTIL ch = 0C;
      IF Length (TempOp) > 4 THEN    (* Index may be present *)
         i := 4;    (* Index starts at 4 *)
         j := 0;
         REPEAT                          (* put Xi in Oper *)
            ch := TempOp[i];
            Oper[j] := ch;
            INC (i);    INC (j);
         UNTIL ch = 0C;

         IF Oper[j - 2] = ')' THEN
            Oper[j - 2] := 0C;
         ELSE
            Error (Op.Loc, AddrErr);
            RETURN;
         END;

         GetSize (Oper, Op.Xsize);
         IF Op.Xsize = Byte THEN
            Error (Op.Loc, SizeErr);
            RETURN;
         END;

         C := ORD (Oper[1]);
         IF (Oper[0] = 'S') AND (Oper[1] = 'P') THEN
            (* Stack Pointer *)
            Op.X := Areg;
            Op.Xn := 7;
         ELSIF Oper[0] = 'A' THEN
            IF (C >= Zero) AND (C <= Seven) THEN
               Op.X := Areg;
               Op.Xn := C - Zero;
            ELSE
               Error (Op.Loc, SizeErr);
               RETURN;
            END;
         ELSIF Oper[0] = 'D' THEN
            IF (C >= Zero) AND (C <= Seven) THEN
               Op.X := Dreg;
               Op.Xn := C - Zero;
            ELSE
               Error (Op.Loc, SizeErr);
               RETURN;
            END;
         ELSE
            Error (Op.Loc, AddrErr);
            RETURN;
         END;

         IF (TempOp[1] = 'P') AND (TempOp[2] = 'C') THEN
            Op.Mode :=PCDisX;
            RETURN;
         ELSIF (TempOp[1] = 'S') AND (TempOp[2] = 'P') THEN
            (* Stack Pointer *)
            Op.Rn := 7;
            Op.Mode := ARDisX;
            RETURN;
         ELSIF TempOp[1] = 'A' THEN
            C := ORD (TempOp[2]);
            IF (C >= Zero) AND (C <= Seven) THEN
               Op.Rn := C - Zero;
               Op.Mode := ARDisX;
               RETURN;
            ELSE
               Error (Op.Loc, SizeErr);
               RETURN;
            END;
         ELSE
            Error (Op.Loc, AddrErr);
            RETURN;
         END;
      ELSE    (* No Index *)
         IF (TempOp[1] = 'P') AND (TempOp[2] = 'C') THEN
            Op.Mode := PCDisp;
            RETURN;
         ELSIF (TempOp[1] = 'S') AND (TempOp[2] = 'P') THEN
            (* Stack Pointer *)
            Op.Mode := ARDisp;
            Op.Rn := 7;
            RETURN;
         ELSIF TempOp[1] = 'A' THEN
            C := ORD (TempOp[2]);
            IF (C >= Zero) AND (C <= Seven) THEN
               Op.Rn := C - Zero;
               Op.Mode := ARDisp;
               RETURN;
            ELSE
               Error (Op.Loc, SizeErr);
               RETURN;
            END;
         ELSE
            Error (Op.Loc, AddrErr);
            RETURN;
         END;
      END;
   END;

   (* Check to see if this could be a register list for MOVEM: *)
   i := 0;
   MultFlag := FALSE;
   LOOP
      ch := Oper[i];    INC (i);
      IF ch = 0C THEN
         MultFlag := FALSE;
         EXIT;
      END;
      IF (ch = 'A') OR (ch = 'D') THEN
         ch := Oper[i];    INC (i);    C := ORD (ch);
         IF ch = 0C THEN
            MultFlag := FALSE;
            EXIT;
         END;
         IF (C >= Zero) AND (C <= Seven) THEN
            ch := Oper[i];    INC (i);
            IF ch = 0C THEN
               EXIT
            END;
            IF (ch = '/') OR (ch = '-') THEN
               MultFlag := TRUE;
            END;
         ELSE
            MultFlag := FALSE;
            EXIT;
         END;
      ELSE
         MultFlag := FALSE;
         EXIT;
      END;
   END;
   IF MultFlag THEN
      Op.Mode := MultiM;
      RETURN;
   END;

   (* Must be absolute mode! *)
   IF Pass2 THEN
      GetValue (Oper, Op.Value);
   END;
   IF AbsSize = Word THEN
      Op.Mode := AbsW;
   ELSE
      Op.Mode := AbsL;
   END;
END GetOperand;


PROCEDURE GetMultReg (Oper : OPERAND; PreDec : BOOLEAN;
                      Loc : CARDINAL; VAR MultExt : BITSET);
(* Builds a BITSET marking each register used in a MOVEM instruction *)

   TYPE
      MReg = (D0, D1, D2, D3, D4, D5, D6, D7,
              A0, A1, A2, A3, A4, A5, A6, A7);

   VAR
      i, j : CARDINAL;
      ch : CHAR;
      C : CARDINAL;    (* ORD value of ch *)
      T1, T2 : MReg;    (* Temporary variables for registers *)
      RegStack : ARRAY [0..15] OF MReg;    (* Holds specified registers *)
      SP : CARDINAL;    (* Pointer for Register Stack *)
      RegType : (D, A, Nil);
      Range : BOOLEAN;

   BEGIN
      SP := 0;
      Range := FALSE;
      RegType := Nil;
      i := 0;

      ch := Oper[i];
      WHILE ch # 0C DO
         IF SP > 15 THEN
            Error (Loc, SizeErr);
            RETURN;
         END;

         C := ORD (ch);
         IF ch = 'A' THEN
            IF RegType = Nil THEN
               RegType := A;
            ELSE
               Error (Loc, OperErr);
               RETURN;
            END;
         ELSIF ch = 'D' THEN
            IF RegType = Nil THEN
               RegType := D;
            ELSE
               Error (Loc, OperErr);
               RETURN;
            END;
         ELSIF (C >= Zero) AND (C <= Seven) THEN
            IF RegType # Nil THEN
               T2 := VAL (MReg, (ORD (RegType) * 8) + (C - Zero));
               IF Range THEN
                  Range := FALSE;
                  T1 := RegStack[SP - 1];    (* retreive 1st Reg in range *)
                  FOR j := (ORD (T1) + 1) TO ORD (T2) DO
                     RegStack[SP] := VAL (MReg, j);
                     INC (SP);
                  END;
               ELSE
                  RegStack[SP] := T2;
                  INC (SP);
               END;
            ELSE
               Error (Loc, OperErr);
               RETURN;
```

(continued on page 58)

PROBLEM: There's just no easy way to move from one software program to another.

THE SOFTLOGIC SOLUTION: Software Carousel

Now you can keep up to 10 programs loaded and ready to run.

Hard to believe, but some people are happy with just one kind of PC software. Well, this is not a product for them.

But if you're someone who depends on many packages, all the time—someone who'd use several programs at once if you could, well now you can. With Software Carousel.

With Software Carousel running in RAM, you can load a program and retrieve a file up to 15 times faster. Test conducted on an IBM XT

Why call it "Software Carousel"?

In some ways, Software Carousel works like the slide projector you're used to. You load a handful of pictures, view one at a time, then quickly switch to another. A simple idea, with powerful possibilities for computing.

Here's how it works. When you start Software Carousel, just tell it how much memory you have, load your software and go to work.

Need to crunch numbers? Switch to your spreadsheet. Need your word processor? Don't bother saving your spreadsheet file. Just whip over to your document and do your work. Snap back to your spreadsheet, and it's just like you left it.

With up to ten different programs at your fingertips, you'll have instant access to your database, communications, spelling checker, spreadsheet, word processor, RAM resident utilities, languages, anything you like.

Reach deep into expanded memory.

This could be the best reason ever for owning an expanded memory card, like the Intel Above Board, AST RAMpage, or any card compatible with the L/I/M Extended Memory Standard.

Software Carousel puts programs into this "high-end" memory for temporary storage when they're not in use. And switches them back out when you want them. It's fast, efficient, and easy.

If you want, Software Carousel will even use your hard drive for swapping. Just allocate a portion for storage, and go to work.

Sidekick, Superkey and Ready. All at the same time.

You know what happens if you try loading two or more RAM resident utilities at once. You get crashed keyboards, frozen screens, all kinds of interference between programs fighting for control.

With Software Carousel, you can have as many accessories and utilities on-tap as you want. Just load different ones in different Carousel partitions. Since they can't see each other, they can't fight.

The easy way to maximize PC power.

With all this power, you might think Software Carousel is complicated and difficult to use. Not so. Set it up once, and it will remember forever. Better still, Carousel will look for the programs you use most often, and optimize them for the quickest access.

You can spend a lot more money, and still not get the convenience and productivity increase of Software Carousel.

The way we see it, there are certain things you have the right to expect from your computer. Access to your software is one of them. And at our special introductory price of just $49.95*, Software Carousel is the best way to get it.

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*plus $5.00 shipping and handling.

Circle **no. 284** on reader service card.

Listing Eighteen (listing continued)

```
            END;
         ELSIF ch = '-' THEN
            IF (Range = FALSE) AND (RegType # Nil) AND (i > 0) THEN
               RegType := Nil;
               Range := TRUE;
            ELSE
               Error (Loc, OperErr);
               RETURN;
            END;
         ELSIF ch = '/' THEN
            IF (Range = FALSE) AND (RegType # Nil) AND (i > 0) THEN
               RegType := Nil;
            ELSE
               Error (Loc, OperErr);
               RETURN;
            END;
         ELSE
            Error (Loc, OperErr);
            RETURN;
         END;

         INC (i);
         ch := Oper[i];
      END;

      MultExt := {};
      FOR j := 0 TO SP - 1 DO
         C := ORD (RegStack[j]);
         IF PreDec THEN
            C := 15 - C;
         END;
         INCL (MultExt, C);
      END;
   END GetMultReg;

END SyntaxAnalyzer.
```

End Listing Eighteen

Listing Nineteen

```
IMPLEMENTATION MODULE Listing;
(* Creates a program listing, including Addresses, Code & Source. *)

   FROM Files IMPORT
      FILE, Write;

   FROM LongNumbers IMPORT
      LONG, LongPut;

   FROM Parser IMPORT
      TOKEN, Line;

   FROM SymbolTable IMPORT
      ListSymTab;

   FROM Conversions IMPORT
      CardToStr;

   IMPORT ASCII;


   CONST
      LnMAX = 55;


   VAR
      LnCnt : CARDINAL;    (* counts number of lines per page *)
      PgCnt : CARDINAL;    (* count of page numbers *)


   PROCEDURE WriteStrF (f : FILE; Str : ARRAY OF CHAR);
   (* Writes a string to the file *)

      VAR
         i : CARDINAL;

      BEGIN
         i := 0;
         WHILE Str[i] # 0C DO
            Write (f, Str[i]);
            INC (i);
         END;
      END WriteStrF;


   PROCEDURE CheckPage (f : FILE);
   (* Checks if end of page reached yet -- if so, advances to next page. *)

      VAR
         i : CARDINAL;
         PgCntStr : ARRAY [0..6] OF CHAR;

      BEGIN
         INC (LnCnt);
         IF LnCnt >= LnMAX THEN
            LnCnt := 1;
            INC (PgCnt);
            Write (f, ASCII.ff);    (* Form Feed for new page *)
            IF CardToStr (PgCnt, PgCntStr) THEN    (* Print New Page Number *)
               FOR i := 1 TO 60 DO
                  Write (f, ' ');
               END;

               WriteStrF (f, "Page ");
               WriteStrF (f, PgCntStr);
            END;
            FOR i := 1 TO 3 DO
               Write (f, ASCII.cr);
               Write (f, ASCII.lf);
            END;
         END;
      END CheckPage;


   PROCEDURE StartListing (f : FILE);
   (* Sign on messages for listing file -- initialize *)
      BEGIN
         Write (f, ASCII.ff);    (* Start on a clean page *)

         WriteStrF (f, "                    68000 Cross Assembler");
         Write (f, ASCII.cr);
         Write (f, ASCII.lf);

         WriteStrF (f, "          Copyright (c) 1985 by Brian R. Anderson");
         Write (f, ASCII.cr);
         Write (f, ASCII.lf);

         Write (f, ASCII.cr);
         Write (f, ASCII.lf);

         LnCnt := 1;
         PgCnt := 1;
      END StartListing;


   PROCEDURE WriteListLine (f : FILE;
                            AddrCnt, ObjOp, ObjSrc, ObjDest : LONG;
                               nA,     nO,     nS,     nD    : CARDINAL);
   (* Writes one line to the Listing file, including Object Code *)

      CONST
         ObjMAX = 30;

      VAR
         i : CARDINAL;

      BEGIN
         IF nA = 0 THEN    (* nA is always either 0 or 6.  Address field = 8 *)
            FOR i := 1 TO 8 DO
               Write (f, ' ');
            END;
         ELSE
            LongPut (f, AddrCnt, 6);
            Write (f, ' ');
            Write (f, ' ');
         END;
         LongPut (f, ObjOp, nO);
         LongPut (f, ObjSrc, nS);
         LongPut (f, ObjDest, nD);
         i := 8 + nO + nS + nD;
         WHILE i < ObjMAX DO
            Write (f, ' ');
            INC (i);
         END;



         WriteStrF (f, Line);
         Write (f, ASCII.cr);
         Write (f, ASCII.lf);

         CheckPage (f);

      END WriteListLine;


   PROCEDURE WriteSymTab (f : FILE; NumSym : CARDINAL);
   (* Lists symbol table in alphabetical order *)

      VAR
         Label : TOKEN;
         Value : LONG;
         i : CARDINAL;

      BEGIN
         LnCnt := 1;
         INC (PgCnt);

         WriteStrF (f, "              * * *  Symbolic Reference Table  * * *");
         FOR i := 1 TO 3 DO
            Write (f, ASCII.cr);
            Write (f, ASCII.lf);
         END;

         FOR i := 1 TO NumSym DO
            ListSymTab (i, Label, Value);
            WriteStrF (f, Label);
            WriteStrF (f, "  :  ");
            LongPut (f, Value, 8);
            Write (f, ASCII.cr);
            Write (f, ASCII.lf);
            CheckPage (f);
         END;

         Write (f, ASCII.ff);
      END WriteSymTab;
```

End Listing Nineteen

Listing Twenty

```
IMPLEMENTATION MODULE Srecord;
(* Creates Motorola S-records of program:          *)
(*    S0 = header record,                          *)
(*    S2 = code/data records (24 bit address),     *)
(*    S8 = termination record (24 bit address).    *)

   FROM Files IMPORT
      FILE, Write;

   FROM Strings IMPORT
      Length;
```

(continued on page 60)

PROBLEM: Handling your need for more megabytes, without spending megabucks on a new drive.

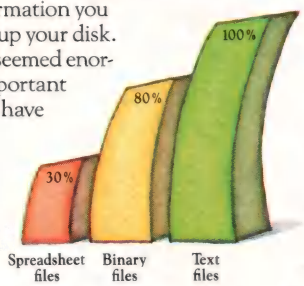
THE SOFTLOGIC SOLUTION: Cubit™

Now get up to twice the capacity from all your storage media.

You know what happens. The more you use your computer, the more information you create. And the faster you fill up your disk.

The 10MB drive that once seemed enormous is now jammed with important files. That 20MB that should have lasted years is crowded in a matter of months.

Of course you could keep buying bigger hard drives. Or you could get Cubit and get the maximum storage space from the drives you already have.



With Cubit, you'll get as much as 100% compression on data files, effectively doubling the storage capacity of all your magnetic media.

What is Cubit?

In brief, Cubit is an advanced software tool that automatically reduces the number of bytes required to store a file, then converts the file back to its original size when retrieved. Some programmers call this effect "data compression," others, "disk expansion." Either way, the result is the same.

Here's how it works. When Cubit compresses a file, it first compares each word to its massive English word dictionary. Words that match are reduced to a predetermined code of just one, two or three bytes each. It then saves the abbreviated version to disk. Decompression works just the opposite.

To accommodate other words and symbols, Cubit uses two more compression techniques. One assigns new, shorter codes to unusual words. Another compresses according to the frequency of character strings in non-text data. So no matter what kind of files you create, Cubit ensures maximum space savings.

Best of all, you'll be using the same fast, reliable data compression techniques used on mainframe computers for decades.

How much disk space will you save?

Because the vast majority of data created on PC's is standard ASCII text—letters, numbers and other English language symbols—we've optimized Cubit for word processing and database files. With these, you'll get a minimum of 50% expansion on up to a full 100% or more.

At the same time, you can expect a significant 30% to 50% improvement with other kinds of data. Including spreadsheet files, program code, graph and image files, even binary data.

And Cubit works just as well with floppies and tape cassettes as it does with hard disk drives.

Run Cubit where you want, when you want.

Maybe you'll want to use Cubit for all your files, or maybe just some. So Cubit lets you specify exactly which files to work on and which ones to leave alone.

In RAM resident mode, Cubit works quickly and invisibly, compressing and decompressing right from within any program you run. Or use Cubit's powerful file management mode. It supports wild-card and global file names, and addresses sub-directories up to thirty levels deep.

Save time and money, as well as disk space.

A compressed file is a smaller file. So with Cubit, back-ups take less time, as well as less space. And communicating compressed files means significant savings on phone line charges.

Any way you look at it, Cubit will pay for itself in no time. And that's especially true now.

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Circle **no. 293** on reader service card.

Listing Twenty (listing continued)

```
FROM LongNumbers IMPORT
   LONG, LongAdd, LongSub, LongInc, LongDec, LongClear,
   LongCompare, CardToLong, LongPut;

IMPORT ASCII;


CONST
   CountMAX = 16;
   SrecMAX = CountMAX * 2;
   XrecMAX = SrecMAX;


VAR
   StartAddr : LONG;    (* address that record starts on *)
   TempAddr : LONG;     (* running address of where we are now *)
   CheckSum : LONG;
   Count : CARDINAL;    (* count of HEX-pairs in S-record *)
   Sdata : ARRAY [1..SrecMAX] OF INTEGER;    (* S-record data, HEX digits *)
   Sindex : CARDINAL;    (* index for Sdata array *)
   Xdata : ARRAY [1..XrecMAX] OF INTEGER;    (* Overflow for Sdata *)
   Xindex : CARDINAL;    (* index for Xdata array *)
   Boundary : BOOLEAN;    (* marks Address MOD 16 boundary of S-record *)
   LZero : LONG;    (* used as a constant = 0 *)


PROCEDURE Complement;    (* CheckSum *)
   BEGIN
      LongSub (LZero, CheckSum, CheckSum);    (* 2's Complement *)
      LongDec (CheckSum, 1);    (* Make it 1's Complement *)
   END Complement;


PROCEDURE AppendSdata (Data : LONG; n : CARDINAL) : BOOLEAN;
(* Transfers data to Sdata, and updates Count & CheckSum. *)
(*    If no room: Data goes to Xdata & FALSE returned.    *)

   VAR
      T : LONG;    (* temporary -- used only as a 2 digit HEX number *)

   BEGIN
      T := LZero;

      WHILE (n # 0) AND (Count # CountMAX) AND (NOT Boundary) DO
         Sdata[Sindex] := Data[n];
         Sdata[Sindex - 1] := Data[n - 1];

         T[2] := Data[n];    T[1] := Data[n - 1];
         LongAdd (T, CheckSum, CheckSum);

         DEC (n, 2);
         DEC (Sindex, 2);
         INC (Count);

         LongInc (TempAddr, 1);
         IF TempAddr[1] = 0 THEN    (* i.e., TempAddr MOD 16 = 0 *)
            Boundary := TRUE;
         END;
      END;

      IF (Count = CountMAX) OR (Boundary) THEN
         WHILE n > 0 DO    (* Add Data to Xdata (in reverse) *)
            INC (Xindex);
            Xdata[Xindex] := Data[n];
            DEC (n);
         END;

         RETURN FALSE;    (* Sdata is full *)
      ELSE
         RETURN TRUE;
      END;
   END AppendSdata;


PROCEDURE DumpSdata (f : FILE);
(* Writes an S2 record to the file *)

   VAR
      T : LONG;    (* temporary -- used to output Count & CheckSum *)
      i, j : CARDINAL;

   BEGIN
      IF Count = 0 THEN
         RETURN;    (* nothing to dump *)
      END;

      Write (f, 'S');
      Write (f, '2');

      CardToLong (Count + 4, T);    (* extra for Address & Checksum *)
      LongPut (f, T, 2);
      LongAdd (T, CheckSum, CheckSum);    (* Add Count to CheckSum *)

      LongPut (f, StartAddr, 6);
      (* Add Address to CheckSum *)
      T := LZero;
      T[1] := StartAddr[1];    T[2] := StartAddr[2];
      LongAdd (T, CheckSum, CheckSum);
      T[1] := StartAddr[3];    T[2] := StartAddr[4];
      LongAdd (T, CheckSum, CheckSum);
      T[1] := StartAddr[5];    T[2] := StartAddr[6];
      LongAdd (T, CheckSum, CheckSum);

      IF Count < CountMAX THEN    (* adjust short record -- shuffle down *)
         j := 1;
         FOR i := Sindex + 1 TO SrecMAX DO
            Sdata[j] := Sdata[i];
            INC (j);
         END;
      END;
      LongPut (f, Sdata, Count * 2);    (* S-record Code/Data *)

      Complement; (* CheckSum *)
      LongPut (f, CheckSum, 2);



      Write (f, ASCII.cr);
      Write (f, ASCII.lf);

      LongInc (StartAddr, Count);
      Sindex := SrecMAX;
      Count := 0;
      Boundary := FALSE;
      CheckSum := LZero;
   END DumpSdata;


PROCEDURE GetXdata;
(* Transfer Xdata into new Sdata line -- N.B.: Xdata stored in reverse *)

   VAR
      i : CARDINAL;
      T : LONG;

   BEGIN
      i := 1;
      T := LZero;

      (* No need for either of the tests (CountMAX or Boundary)    *)
      (* used in AppendSdata.  GetXdata is only ever called        *)
      (* after DumpSdata and is therefore only putting (up to 20)  *)
      (* HEX digits in an empty buffer (which could hold 32).      *)
      WHILE i < Xindex DO
         Sdata[Sindex] := Xdata[i];
         Sdata[Sindex - 1] := Xdata[i + 1];
         T[2] := Sdata[Sindex];    T[1] := Sdata[Sindex - 1];
         LongAdd (T, CheckSum, CheckSum);
         INC (i, 2);
         DEC (Sindex, 2);
         INC (Count);
         LongInc (TempAddr, 1);
      END;

      Xindex := 0;
   END GetXdata;


PROCEDURE StartSrec (f : FILE; SourceFN : ARRAY OF CHAR);
(* Writes S0 record (HEADER) and initializes *)

   VAR
      T : LONG;    (* temporary *)
      i : CARDINAL;

   BEGIN
      Write (f, 'S');
      Write (f, '0');

      CheckSum := LZero;
      Count := Length (SourceFN) + 3;    (* extra for Address & Checksum *)
      CardToLong (Count, T);
      LongPut (f, T, 2);
      LongAdd (T, CheckSum, CheckSum);

      LongPut (f, LZero, 4);    (* Address is 4 digit, all zero, for S0 *)

      i := 0;
      WHILE SourceFN[i] # 0C DO
         CardToLong (ORD (SourceFN[i]), T);
         LongAdd (T, CheckSum, CheckSum);
         LongPut (f, T, 2);
         INC (i);
      END;

      Complement;    (* CheckSum *)
      LongPut (f, CheckSum, 2);

      Write (f, ASCII.cr);
      Write (f, ASCII.lf);

      Sindex := SrecMAX;
      Xindex := 0;
      Count := 0;
      Boundary := FALSE;
      CheckSum := LZero;
      StartAddr := LZero;
      TempAddr := LZero;
   END StartSrec;


PROCEDURE WriteSrecLine (f : FILE;
                         AddrCnt, ObjOp, ObjSrc, ObjDest : LONG;
                            nA,     nO,     nS,      nD    : CARDINAL);
(* Collects Object Code -- Writes an S2 record to file if line is full *)

   VAR
      dummy : BOOLEAN;

   BEGIN
      IF nA = 0 THEN
         RETURN;    (* Nothing to add to S-record *)
      END;

      IF Xindex # 0 THEN
         GetXdata;    (* transfers Xdata into Sdata *)
      END;

      IF LongCompare (AddrCnt, TempAddr) # 0 THEN
         DumpSdata (f);
      END;

      IF Count = 0 THEN
         StartAddr := AddrCnt;
         TempAddr := AddrCnt;
      END;

      dummy := AppendSdata (ObjOp, nO);
      dummy := AppendSdata (ObjSrc, nS);
      IF NOT AppendSdata (ObjDest, nD) THEN
         DumpSdata (f);
      END;
   END WriteSrecLine;


PROCEDURE EndSrec (f : FILE);
(* Finishes off any left-over (Partial) S2 line, *)
(* and then writes S8 record (TRAILER)            *)
   BEGIN
      IF Xindex # 0 THEN
         GetXdata;



         END;
         DumpSdata (f);

         Write (f, 'S');    (* Fixed format for S8 record *)
         Write (f, '8');
         Write (f, '0');
         Write (f, '4');
         Write (f, '0');
         Write (f, '0');
         Write (f, '0');
```

(continued on page 62)

PROBLEM: The more experience your hard disk has, the harder it has to work.

THE SOFTLOGIC SOLUTION: Disk Optimizer™

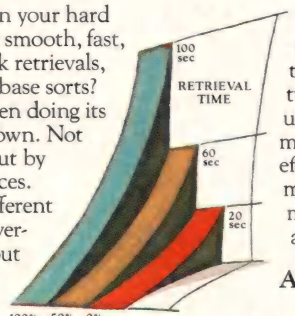
Your hard disk will run faster when it's not chasing around after files.

Remember the old days when your hard drive was new? Remember that smooth, fast, slick performance? Those quick retrievals, rapid saves, lightning-like database sorts?

Well ever since, DOS has been doing its best to slow your hard drive down. Not by slowing down the motor, but by breaking your files up into pieces. Storing different chunks in different places. Data files, programs, overlays and batches that started out in one seamless piece are now scattered all over.

Loading is slower. Sorting is slower. Retrieving, backing-up. Everything takes longer because your disk has to work harder.

Problem is, it's something that happens so gradually you may not notice the difference. At least, not until you see the dramatic improvement after using Disk Optimizer.



The more fragmented your files get, the longer they take to retrieve.

File fragmentation—It's a problem you can see.

Watch your hard drive the next time it reads or writes a file. Each "blip" of the LED means the drive-head is moving to another place on the disk—either to pick up or lay down another chunk of data.

And the truth is, head movement takes time. Far more time than actual reading and writing. What's worse, all this head movement causes extra wear and tear that can shorten the life of your drive.

Disk Optimizer—Tunes up your disk by cleaning up your files.

Disk Optimizer works by finding all the scattered pieces of your files and putting them back together where they belong. Next time your drive reads it, there's just one place to look.

And the results are often dramatic. Reading and writing times may be cut by as much as two thirds. Database sorts that used to take hundreds of head moves now proceed quickly and efficiently. And since head movement is now at an absolute minimum, your disk drive will lead a longer, more productive life.

Analyze, scrutinize, optimize.

Before you optimize, you'll probably want to analyze. So Disk Optimizer shows you, in percentages, how much fragmentation has taken place—on the entire disk, in individual directories, or for groups of files you specify using global or wildcard names.

Plus, there's built-in data security that lets you assign passwords to as many files or file groups as you want.

And the File Peeker gives you an inside look at the structure of files. It's a great way for non-programmers to learn more about computers, and a powerful tool for professionals who want to analyze the contents of their disks.

Get your hard drive back in shape—at a special low price.

When you think about it, it's simple. The longer you own your hard drive, the more you come to depend on it. But the longer you wait to get Disk Optimizer, the less performance you'll have.

And the less chance you'll have to buy Disk Optimizer at the special introductory price of just $49.95*.

That's a small price to pay to get back the speed you depend on. But it's a price that won't last long.

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*plus $5.00 shipping and handling.

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Listing Twenty (listing continued)

```
         Write (f, '0');
         Write (f, '0');
         Write (f, '0');
         Write (f, 'F');
         Write (f, 'C');
         Write (f, ASCII.cr);
         Write (f, ASCII.lf);
         Write (f, ASCII.cr);
         Write (f, ASCII.lf);
      END EndSrec;

BEGIN   (* Initialization *)
   LongClear (LZero);
END Srecord.
```

End Listing Twenty

Listing Twenty-One

```
IMPLEMENTATION MODULE ErrorX68;
(* Displays error messages for X68000 cross assembler *)

   FROM Terminal IMPORT
      WriteString, WriteLn;

   IMPORT Terminal;   (* for Read/Write *)

   FROM Files IMPORT
      FILE;

   IMPORT Files;   (* for Write *)

   FROM Strings IMPORT
      Length;

   FROM Conversions IMPORT
      CardToStr;

   IMPORT ASCII;

   FROM Parser IMPORT
      Line, LineCount;


(*---
   TYPE
      ErrorType = (Dummy, TooLong, NoCode, SymDup, Undef, SymFull, Phase,
                   ModeErr, OperErr, BraErr, AddrErr, SizeErr, EndErr);

   VAR
      ErrorCount : CARDINAL;
                                                                    ---*)

   VAR
      FirstTime : BOOLEAN;


   PROCEDURE FileWriteString (f : FILE; VAR Str : ARRAY OF CHAR);

      VAR
         i : CARDINAL;

      BEGIN
         i := 0;
         WHILE Str[i] # 0C DO
            Files.Write (f, Str[i]);
            INC (i);
         END;
      END FileWriteString;


   PROCEDURE Error (Pos : CARDINAL; ErrorNbr : ErrorType);
   (* Displays Error #ErrorNbr, then waits for any key to continue *)

      VAR
         i : CARDINAL;
         c : CHAR;
         CntStr : ARRAY [0..6] OF CHAR;
         dummy : BOOLEAN;

      BEGIN
         WriteLn;
         dummy := CardToStr (LineCount, CntStr);
         WriteString (CntStr);
         WriteString ("    ");
         WriteString (Line);   WriteLn;

         (* Make up for LineCnt so ^ in right spot *)
         FOR i := 1 TO Length (CntStr) DO
            Terminal.Write (' ');
         END;
         WriteString ("    ");

         IF Pos > 0 THEN
            FOR i := 1 TO Pos DO
               Terminal.Write (' ');
            END;
            Terminal.Write ('^');   WriteLn;
         END;

         CASE ErrorNbr OF
            TooLong : WriteString ("Identifier too long -- Truncated!");
         |  NoCode  : WriteString ("No such op-code.");
         |  SymDup  : WriteString ("Duplicate Symbol.");
         |  Undef   : WriteString ("Undefined Symbol.");
         |  SymFull : WriteString ("Symbol Table Full -- Maximum = 500!");
                      WriteLn;
                      WriteString ("Program Terminated.");   WriteLn;
                      HALT;
         |  Phase   : WriteString ("Pass 1/Pass 2 Address Count Mis-Match.");
         |  ModeErr : WriteString ("This addressing mode not allowed here.");
         |  OperErr : WriteString ("Error in operand format.");
         |  BraErr  : WriteString ("Error in relative branch.");
         |  AddrErr : WriteString ("Address mode error.");
         |  SizeErr : WriteString ("Operand size error.");
         |  EndErr  : WriteString ("Missing END Pseudo-Op.");
         ELSE
            WriteString ("Unknown Error.");
         END;
         WriteLn;

         IF FirstTime THEN
            WriteString ("Hit any key to continue.... ");
            Terminal.Read (c);
            WriteLn;
            FirstTime := FALSE;
         ELSE
            Terminal.Read (c);
         END;

         INC (ErrorCount);
         IF ErrorCount > 500 THEN
            WriteString ("Too many errors!");   WriteLn;
            WriteString ("Program Terminated.");   WriteLn;
            HALT;
         END;
      END Error;


PROCEDURE WriteErrorCount (f : FILE);
(* Error count output to Console & Listing file *)

   VAR
      CntStr : ARRAY [0..6] OF CHAR;
      Msg0 : ARRAY [0..25] OF CHAR;

         Msg1 : ARRAY [0..10] OF CHAR;
         Msg2 : ARRAY [0..20] OF CHAR;
         dummy : BOOLEAN;

      BEGIN
         Msg0 := "--->   END OF ASSEMBLY";
         Msg1 := "--->    ";
         Msg2 := " ASSEMBLY ERROR(S).";
         dummy := CardToStr (ErrorCount, CntStr);

         (* Messages to console *)
         WriteLn;
         WriteLn;
         WriteString (Msg0);   WriteLn;
         WriteString (Msg1);
         WriteString (CntStr);
         WriteString (Msg2);
         WriteLn;

         (* Messages to listing file *)
         Files.Write (f, ASCII.cr);
         Files.Write (f, ASCII.lf);
         Files.Write (f, ASCII.cr);
         Files.Write (f, ASCII.lf);

         FileWriteString (f, Msg0);
         Files.Write (f, ASCII.cr);
         Files.Write (f, ASCII.lf);

         FileWriteString (f, Msg1);
         FileWriteString (f, CntStr);
         FileWriteString (f, Msg2);
         Files.Write (f, ASCII.cr);
         Files.Write (f, ASCII.lf);

         Files.Write (f, ASCII.ff);   (* feed up next page *)
      END WriteErrorCount;

BEGIN   (* MODULE Initialization *)
   FirstTime := TRUE;
   ErrorCount := 0;
END ErrorX68.
```

End Listings

M A K E • T H E • C O N N E C T I O N

Lattice

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		LIST	OURS
Lattice C Compiler		500	299
	with Library Source Code	900	549

Popular, industry standard C compiler that features fast compilation, efficient code generation, support for 80186/286 instructions and inline support of 8087/287 instructions. The latest version now supports void, enum, unsigned as a modifier and function prototype checking. The library contains more than 325 functions compatible with UNIX, XENIX and the proposed ANSI standard, plus extensive support for MS-DOS versions 2.+ and 3.+. Other useful Lattice C features include support for nested comments, extended symbol length and multiple memory models. It comes with an object module disassembler, a function extract utility, a full set of libraries for each supported memory model, sample programs and extensive documentation. Requires 128K memory.

The C-Food Smorgasbord	Binary	150	99
	with Source Code	300	195

General C function library featuring BCD (binary coded decimal) arithmetic, level 0 I/O, BIOS interface, terminal independence, directory, clock, string and other miscellaneous functions. No royalties. For use with Lattice C.

C-SPRITE		175	139

Program debugger with source level support for Lattice C that includes help screens, macros, command files, conditional commands, debugging through a COM port and support for Plink86 overlays. The source mode supports all debugging functions including disassemble, single-step and breakpoints. The data types of symbols may be completely specified so that variables can be properly displayed. There is also complete assembly language support providing direct access to machine addresses and instructions. Requires 256K memory. Specify C compiler: Lattice or Microsoft.

Curses Screen Manager	Binary	125	99
	with Source Code	250	199

Library of C screen interface functions compatible with curses packages on UNIX systems. You can keep and update any number of full or partial virtual screen images in memory and display them as needed. Functions are provided to write text to virtual screens, move the cursors, scroll the screens, overlay screens, outline, insert, delete, clear and highlight. No royalties. For use with Lattice C.

dBC II or dBC III	Binary	250	199
	with Source Code	500	395

Complete C library of ISAM file management functions for creating and manipulating dBase compatible files. You can easily add, update, delete, retrieve and organize records and indexes in dBase format. Up to eight data and eight index files may be opened and processed simultaneously. Specify dBC II for dBase II type files or dBC III for dBase III type files. No royalties. Requires 128K memory. Specify C compiler: Lattice, Microsoft, Computer Innovations or DeSmet.

LMK Make Utility		195	149

Programming utility to rebuild programs after changes have been made to source files. First, you create a text file consisting of macro definitions, dependency descriptions and executable commands. Then, whenever you make changes to your program, LMK determines which source files need to be recompiled and automatically creates the new program. Requires 128K memory and may be used with any compiler or assembler.

LSE Screen Editor		125	99

Multi-window programmer's editor with block moves, pattern searching and "cut and paste." You can remap any of LSE's 48 keystrokes to suit your own preferences and define your own keyboard macros and default file extensions. The menus, prompts and help messages used in the system can all be customized. Special features include a Lattice C error tracking mode and three assembly language input modes. Requires 128K memory.

RPG II Compiler		750	595

RPG II compiler for MS-DOS that is compatible with IBM System III, System/34 and System/36 RPG II compilers. Special PC extensions include support for standard MS-DOS files, keyboard, function keys and string handling. ISAM files are compatible with dBC III and dBase III files. Requires 192K memory.

SecretDisk		60	49

File security utility for providing complete security for sensitive information on a floppy or hard disk system. You can use either the international Data Encryption Standard (DES) or Lattice's own Fast encryption algorithm for higher speed operation. It's loaded as a DOS device driver and creates new logical DOS drives where all files are fully encrypted. A password is entered when the system is booted and protection can be switched on and off with a single password controlled command line. Without the password, there is no known way to access the encrypted files! Multiple protected areas may be created using different passwords and data backup may be made in either encrypted or unencrypted mode. It does not interfere with normal access to the computer system or to files that are not encrypted.

SideTalk		120	95

Pop-up telecommunications package that can be accessed from inside any application with a single keystroke. It incorporates the SideTalk Communications Language (SCL) consisting of BASIC-like commands that allow you to create your own communications processing system. It provides for multitasking (background) operation, file transfer capabilities, text transfer from background to foreground and DOS commands available in background. Requires less than 64K available memory.

Text Management Utilities		120	95

Includes four text management utilities found under UNIX. The first utility is grep (global regular expression search and print). You provide it with a pattern to find and it displays each line containing that pattern with its line number in that file. In addition, these functions are provided as Lattice C object libraries. The second utility is DIFF, a differential file comparator. It compares two files and determines how they differ from one another. The third utility is ED, a line editor and the fourth utility is WC, a simple word count facility for counting the number of characters, words and lines in a file. Requires 128K memory.

TopView Toolbasket	Binary	250	199
	with Source Code	500	395

Library of C functions for simplifying programming in IBM's TopView environment. It gives you easy access to TopView's window, cursor, pointer facilities, cut-and-paste services and printer control services. It deals with TopView objects through a central dispatching function that can be tailored to your application. Includes excellent error checking and debugging support. Requires 256K memory (512K recommended). For use with Lattice C.

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apl language

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Btrieve *ISAM File Mgr* by SoftCraft	*New version*	250	**195**
Financial/Statistical Library by STSC		275	**219**
FRESCO *Business Graphics System* by Mr. APL		300	**269**
Pocket APL by STSC		95	**79**
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artificial intelligence

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Insight II by Level Five Research		485	**389**
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MicroProlog by Programming Logic Associates	*New*	250	**219**
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Professional MicroProlog by Programming Logic	*New*	395	**349**
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Prolog-86 Plus from Solution Systems	*New*	250	**CALL**
QNIAL by NIAL Systems	*New*	375	**359**
Small-X by Kaplan		125	**99**
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Turbo Prolog Compiler by Borland International	*New*	100	**CALL**

assemblers and debuggers

8088 Assembler *w/Z-80 Translator* by 2500 AD		100	**89**
Advanced Trace-86 by Morgan	*with ASM Interpreter*	175	**139**
Codesmith-86 *Debugger* by Visual Age		145	**109**
Cross Assemblers from 2500AD	*Over 25 varieties*	CALL	**CALL**
Microsoft Macro Assembler with utilities		150	**99**
Periscope I *Debugger* by Data Base Decisions		295	**249**
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basic language

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8087 Math Support		50	**47**
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blaise products

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borland products

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Eco-C *Complete Development System* by Ecosoft		125	**CALL**
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c utilities

Please refer to the following sections for additional products: Blaise, Computer Innovations, Lattice, Microsoft, Phoenix, Polytron, SoftCraft and Xenix System V.

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BasicC Library by C Source		175	**135**
C Essentials by Essential Software	*New*	100	**85**
C-lib by vance info systems		195	**125**
C Power Packs by Software Horizons		CALL	**CALL**
c-tree by FairCom	*Includes source*	395	**329**
C Utility Library by Essential Software		185	**139**
C Windows by Syscom		100	**89**
C Wings by Syscom		50	**45**
dbVISTA *Single-User DBMS* by Raima		195	**159**
with Source Code		495	**429**
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with Source Code		990	**849**
Entelekon C Function Library		130	**115**
Entelekon C Windows		130	**115**
Entelekon Superfonts for C		50	**45**
Entelekon Combination Package		200	**175**
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GraphiC by Scientific Endeavors	*Color version 3.0*	350	**299**
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Greenleaf Comm Library by Greenleaf Software		185	**135**
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cobol language

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computer innovations products

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fortran language

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(6/86)

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microsoft products

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modula-2 language

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other products

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DDJ ON LINE

Listing One (Text begins on page 16.)

```
* PERMG for the 68000.  Inversely permute a 256-bit bit
* vector, BLOCK, by table BITPERM.  On call:
*
*       a0 -> BLOCK, a 32-byte area
*       a1 -> BITPERM, a table of byte values in 0..255
*
* On return, a0 -> permuted BLOCK
*            All registers saved
*
* Register usage:
*       a2 -> WORK, a 32-byte temporary work area
*       a3 -> BLOCK
*       d0 =  outer loop counter
*       d1 =  inner loop counter
*       d3 =  longword from BLOCK
*       d4 =  byte from BITPERM
*       d5 =  temporary
*       d6 =  #7, immediate masking value
* Version of 3/22/86.  Executes in 4 ms on 8 MHz system.

        .globl  permg
        .globl  work

permg:
        movem.l d0-d6/a0-a3,-(a7)
        moveq   #7,d0           clear work area
        lea     work,a2
clrloop:
        clr.l   (a2)+
        dbf     d0,clrloop
        lea     work,a2         init registers
        move.l  a0,a3           save block addr for later
        moveq   #7,d0           outer loop control
        moveq   #0,d2           count of bits
        move    d2,d4           need word clear
        move    d2,d5           need word clear
        moveq   #7,d6           masking value
permg1:
        moveq   #31,d1          inner loop control
        move.l  (a0)+,d3        get longword from BLOCK
bitloop:
        btst    d1,d3           check for bit on
        bne     setbit          if on, set BITPERM[d2] bit in WORK
permg2:
        addq    #1,d2           ...else, bump count
        dbf     d1,bitloop      and do for all bits in this word
        dbf     d0,permg1       do for all words of BLOCK

movloop:
        move.l  (a2)+,(a3)+     move WORK to BLOCK
        dbf     d6,movloop      use #7 already in d6
        movem.l (a7)+,d0-d6/a0-a3
        rts                     all done

setbit:
        move.b  (a1,d2),d4      get byte BITPERM[COUNT]
        move    d4,d5           save for reuse
        lsr     #3,d4           index to byte of WORK
        and     d6,d5           compute bit # in that byte
        eor     d6,d5           reverse bit order
        bset    d5,(a2,d4)      set the bit in WORK
        bra     permg2          re-enter main loop

        .end
```

End Listing One

Listing Two

```
* PERMF for the 68000.  Permute a 256-bit bit vector, BLOCK
* by table BITPERM.  On call:
*
*       a0 -> BLOCK, a 32-byte area
*       a1 -> BITPERM, a table of byte values in 0..255
*
* On return, a0 -> permuted BLOCK.
*            All registers saved.
*
* Register usage:
*       a2 -> WORK, a 32-byte temporary work area
*       d0 =  byte from BITPERM, shifted to bit index
*       d1 =  index to byte of BLOCK
*       d2 =  #3, immediate shift value
*       d3 =  identifies bit in WORK to change
*       d4 =  loop counter for BITPERM values
*       d5 =  identifies bit in WORK to change
*       d6 =  #7, immediate masking value
*       d7 =  temporary
* Version of 3/22/86.   Execution time at 8 MHz = 6 ms.

        .globl  permf
        .globl  work

        .text

permf:
        movem.l d0-d7/a0-a2,-(a7)

        moveq   #7,d0           clear work area
        lea     work,a2
clrloop:
        clr.l   (a2)+
        dbf     d0,clrloop
        lea     work,a2
        moveq   #0,d3           init counter to bits in WORK
        move    #255,d4         init BITPERM loop counter
        moveq   #7,d6           masking value
        moveq   #3,d2           shift value
        clr     d0
permloop:
        move.b  (a1)+,d0        get byte from BITPERM
        move    d0,d1           we will need it twice
        lsr.w   d2,d1           compute byte index in BLOCK
        and     d6,d0           save lower 3 bits for bit index
        eor     d6,d0           reverse bit order for btst
        btst    d0,(a0,d1)      is bit on in BLOCK?
        bne     permf2          if so, we must set bit in WORK
permf1:
        addq    #1,d3           else, next bit of WORK
        dbf     d4,permloop     and next byte of BITPERM

movloop:
        move.l  (a2)+,(a0)+     move WORK to BLOCK
        dbf     d6,movloop      use #7 already in d6
        movem.l (a7)+,d0-d7/a0-a2
        rts                     all done

permf2:
        move    d3,d5           if BLOCK bit is on...
        lsr.w   d2,d5           find permuted bit in WORK...
        move    d3,d7           save d3 for counter
        and     d6,d7           save lower 3 bits
        eor     d6,d7           reverse bit order for bset
        bset    d7,(a2,d5)      set desired bit in WORK
        bra     permf1          re-enter main loop

        .end

        bset    d7,(a2,d5)
```

End Listings

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C CHEST

Listing One (Text begins on page 22.)

```
/*
 *                                SORT.C
 *
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 */

#include <stdio.h>
#include <ctype.h>
#include <getargs.h>

extern char     *malloc();

/*-----------------------------------------------------------------------
 *      General purpose #defines.
 */

#define MAXBUF          (132 + 1)       /* Maximum input line length +1 */
#define MAXLINEC        1024            /* Maximum number of lines in   */
                                        /* an input file before merge   */
                                        /* files start to be created    */
#define MAXTMP          18              /* The maximum number of temp-  */
                                        /* orary files that will be     */
                                        /* created. Note that fp's are  */
                                        /* needed for stdout, and       */
                                        /* stderr during output         */

#define isnum(c1)       ( isdigit(c1) || (c1) == '-' )

/*-----------------------------------------------------------------------
 *      Variables for getargs. The immediately following variables will
 *      be modified by getargs() according to what flags it finds on the
 *      command line.
 */

static int      Noblanks        =  0    ;       /* Blanks don't count    */
static int      Numeric         =  0    ;       /* Sort numbers by val   */
static int      Primary         =  0    ;       /* Primary sort key      */
static int      Secondary       =  0    ;       /* Secondary sort key    */
static int      Dictorder       =  0    ;       /* Use dictionary order  */
static int      Foldupper       =  0    ;       /* Fold upper case       */
static int      Reverse         =  0    ;       /* Sort in reverse order */
static int      Delim           =  0    ;       /* Field separator       */
static char     *Mdir           =  ""   ;       /* Put temp files here   */
static int      Nodups          =  0    ;       /* Don't print duplicate */
                                                /* lines.                */
ARG     Argtab[] =
{
    /* arg     type      variable    error message string     */

      { 'b' , BOOLEAN,   &Noblanks,   "ignore leading whitespace (Blanks)"},
      { 'd' , BOOLEAN,   &Dictorder,  "sort in Dictionary order"          },
      { 'f' , BOOLEAN,   &Foldupper,  "Fold upper into lower case"        },
      { 'n' , BOOLEAN,   &Numeric,    "sort Numbers by numeric value"     },
      { 'p' , INTEGER,   &Primary,    "use field <num> as Primary key"    },
      { 'r' , BOOLEAN,   &Reverse,    "do a reverse sort"                 },
      { 's' , INTEGER,   &Secondary,  "use field <num> as Secondary key"  },
      { 't' , CHARACTER, &Delim,      "use <C> to separate fields"        },
      { 'T' , STRING,    (int*)&Mdir, "prepend <str> to Temp file names"  },
      { 'u' , BOOLEAN,   &Nodups,     "delete duplicate lines in output"  }
};

#define NUMARGS         (sizeof(Argtab) / sizeof(ARG))

/*-----------------------------------------------------------------------
 *      Global variables. The Lines array is used for the initial
 *      sorting.
 */

static  int     Options;                /* Set by main if any options set */
static  char    *Lines[MAXLINEC];       /* Holds arrays of input lines    */
static  int     Linec;                  /* # of items in Lines            */
static  char    **Argv;                 /* Copies of argv and argc        */
static  int     Argc;

/*-----------------------------------------------------------------------
 *      The heap used in the merge process:
 */

typedef struct
{
        char    string[MAXBUF];         /* One line from the merge file */
        FILE    *file;                  /* Pointer to input file        */
}
HEAP;

HEAP    *Heap[ MAXTMP ];                /* The heap itself              */

/*-----------------------------------------------------------------------*/

#ifndef DEBUG
#define pheap(s,n)
#else

pheap( str, n )
char *str;
```

(continued on page 70)

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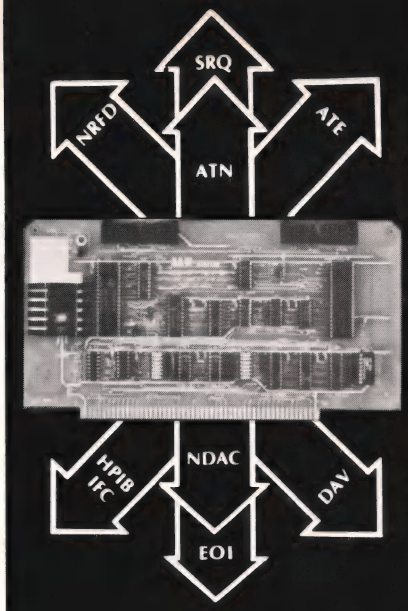
Listing One **(Listing continued, text begins on page 22.)**

```
 97 {
 98         int     i;
 99
100         printf("+-------------------------\n");
101         printf("| %s, heap is:\n", str);
102         for(i = 0; i < n ; i++ )
103         {
104                 printf("|%02d: %s", i, *(Heap[i]->string) ?
105                                         Heap[i]->string  : "(null)\n" );
106         }
107         printf("+-------------------------\n");
108 }
109
110 #endif
111
112 /*-------------------------------------------------------------------------*/
113
114 int     dedupe(argc, argv)
115 int     argc;
116 char    **argv;
117 {
118         /*      Compress an argv-like array of pointers to strings so that
119          *      adjacent duplicate lines are eliminated. Return the
120          *      argument count after the compression.
121          */
122
123         register int    i       ;
124         int             nargc   ;
125         char            **dp    ;
126
127         nargc = 1;
128
129         dp = &argv[1];
130
131         for ( i=1  ;  i < argc ;  i++ )
132         {
133                 if( strcmp(argv[i-1], argv[i]) != 0 )
134                 {
135                         *dp++ = argv[i];
136                         nargc++;
137                 }
138         }
139
140         return( nargc );
141 }
142
143 /*-------------------------------------------------------------------------*/
144
145 static char     *skip_field(n, str)
146 int             n;
147 char            *str;
148 {
149         /*      Skip over n fields. The delimiter is in the global
150          *      variable Delim. Return a pointer to either the character
151          *      to the right of the delimiter, or to the '\0'.
152          */
153
154         while( n > 0   &&   *str )
155         {
156                 if( *str++ == Delim)
157                         --n;
158         }
159
160         return(str);
161 }
162
163 /*-------------------------------------------------------------------------
164  *              Comparison functions needed for sorting.
165  *
166  *      ssort() will call either argvcmp or qcmp, passing them pointers
167  *      to linev entries. qcmp() calls two workhorse functions, qcmp1()
168  *      and qcmp2(). The workhorse functions will also be called by the
169  *      reheap() subroutine used to manipulate merge files.
170  */
171
172 static int      argvcmp( s1p, s2p )
173 char            **s1p, **s2p;
174 {
175         return( strcmp( *s1p, *s2p ) );
176 }
177
178 /*-------------------------------------------------------------------------*/
179
180 static int      qcmp( str1p, str2p )
181 char            **str1p;
182 char            **str2p;
183 {
184         /*      Takes care of all the sorting of fields, calling qcmp1
185          *      to do the actual comparisons. Assuming here that
186          *      Secondary won't be set unless Primary is set too.
187          */
188
189         return( qcmp1( *str1p, *str2p ) );
190 }
191
```

```
192 /*------------------------------------------------------------------------*/
193
194 static int      qcmp1( str1, str2 )
195 char            *str1, *str2;
196 {
197         /*      Workhorse comparison function. Takes care of sorting
198          *      fields. If a primary sort field is specified then
199          *      qcmp1() skips to that field and calls qcmp2 to do the
200          *      actual comparison. If the primary fields are equal, then
201          *      the secondary fields are compared in the same way.
202          */
203
204         int     rval;
205
206         if( !Primary )
207                 return qcmp2( str1, str2 );
208         else
209         {
210                 rval = qcmp2(   skip_field(Primary - 1, str1),
211                                 skip_field(Primary - 1, str2)   );
212
213                 if( !rval && Secondary )
214                 {
215                         /* The two primary keys are equal, search the   */
216                         /* secondary keys if one is specified           */
217
218                         rval = qcmp2(   skip_field(Secondary - 1, str1),
219                                         skip_field(Secondary - 1, str2) );
220                 }
221
222                 return rval;
223         }
224 }
225
226 /*------------------------------------------------------------------------*/
227
228 static int      qcmp2( str1, str2 )
229 char            *str1;
230 char            *str2;
231 {
232         /*      Workhorse comparison function. Deals with all command line
233          *      options except fields. Returns
234          *
235          *              0       if      str1 == str2
236          *              positive if     str1  > str2
237          *              negative if     str1  < str2
238          *
239          *      This is a general purpose (and therefore relatively slow)
240          *      routine. Use strcmp() if you need a fast compare.
241          *      Comparison stops on reaching end of string or on encountering
242          *      a Delim character (if one exists). So make sure Delim is
243          *      set to '\0' if you're not sorting by fields.
244          */
245
246         register unsigned int   c1, c2;
247
248         if( Noblanks )
249         {
250                 /*
251                  *      Skip past leading whitespace in both strings
252                  */
253
254                 while( isspace(*str1) )
255                         str1++;
256
257                 while( isspace(*str2) )
258                         str2++;
259         }
260
261         do
262         {
263                 if( Numeric && isnum(*str1) && isnum(*str2) )
264                 {
265                         /* Add 0xff to the two numeric values so that
266                          * c1 and c2 can't be confused with a Delim
267                          * character later on.
268                          */
269
270                         c1 = stoi( &str1 ) + 0xff ;
271                         c2 = stoi( &str2 ) + 0xff ;
272
273                         if( c1 == c2 )
274                                 continue;
275                         else
276                                 break;
277                 }
278
279                 c1 = *str1++;
280                 c2 = *str2++;
281
282                 if(Dictorder)
283                 {
284                         /*      Skip past any non-alphanumeric or blank
285                          *      characters.
286                          */
287
288                         while( c1 && !isalnum(c1) )
289                                 c1 = *str1++ ;
290
291                         while( c2 && !isalnum(c2) )
292                                 c2 = *str2++ ;
293                 }
```

(continued on next page)



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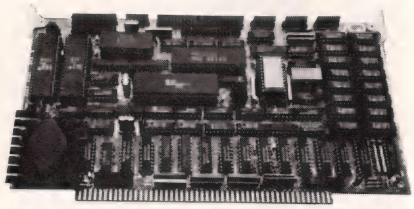

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C CHEST

Listing One **(Listing continued, text begins on page 22.)**

```
294
295
296                 if(Foldupper)
297                 {
298                         /* Map c1 and c2 to upper case  */
299
300                         c1 = toupper( c1 );
301                         c2 = toupper( c2 );
302                 }
303
304                 /* Keep processing while the characters are the same
305                  * unless we've reached end of string or a delimiter.
306                  */
307         }
308         while( (c1==c2)  &&  c1  &&  c1 != Delim );
309
310         if( Delim )                     /* If we're sorting on a field  */
311         {                               /* and we've found a delimiter  */
312                 if(c1 == Delim)         /* then map the delimiter to a  */
313                         c1 = 0;         /* zero for purposes of         */
314                                         /* comparison.                  */
315                 if(c2 == Delim)
316                         c2 = 0;
317         }
318
319         return( Reverse ? (c2 - c1) : (c1 - c2) );
320 }
321
322 /*------------------------------------------------------------------------*/
323
324 FILE    *nextfile()
325 {
326         /*      Return a FILE pointer for the next input file or NULL
327          *      if no more input files exist (ie. all of the files
328          *      on the command line have been processed) or a file
329          *      can't be opened. In this last case print an error message.
330          *      If Argc == 1 the first time we're called, then standard
331          *      input is returned (the first time only , NULL is returned
332          *      on subsequent calls).
333          */
334
335         FILE            *fp;
336         static  int     first_time = 1 ;
337
338         if( first_time )
339         {
340                 first_time = 0;
341                 if( Argc == 1 )
342                         return stdin;
343         }
344
345         if( Argc-- > 1 )
346         {
347                 if( !(fp = fopen(*++Argv, "r")) )
348                         fprintf(stderr, "sort: can't open %s for read\n",
349                                                                 *Argv );
350                 return fp;
351         }
352
353         return NULL;
354 }
355
356 /*------------------------------------------------------------------------*/
357
358 gtext()
359 {
360         /*      Get text from the appropriate input source and put
361          *      the lines into Linev, updating Linec. Return non-zero
362          *      if more input remains. Note that non-zero will
363          *      be returned if there are exactly MAXLINEC lines in
364          *      the input, even though there isn't any more actual
365          *      input available. If malloc can't get space for the line,
366          *      we'll remember the line in buf and return 1.
367          */
368
369         register int    c;
370         static FILE     *fp             =  0;
371         static char     buf[ MAXBUF ]   = {0};          /* Input buffer */
372         int             maxcount;
373         char            **lv;
374
375         if( !fp )                       /* This is only true the first  */
376                 fp = nextfile();        /* time we're called.           */
377
378         lv    = Lines ;
379         Linec = 0     ;
380
381         for( maxcount = MAXLINEC;  --maxcount >= 0 ;)
382         {
383                 if( !*buf )
384                         while( fgets(buf, MAXBUF, fp) == NULL )
385                                 if( !(fp = nextfile()) )
386                                         return( 0 );        /* No more input */
387
```

(continued on page 81)

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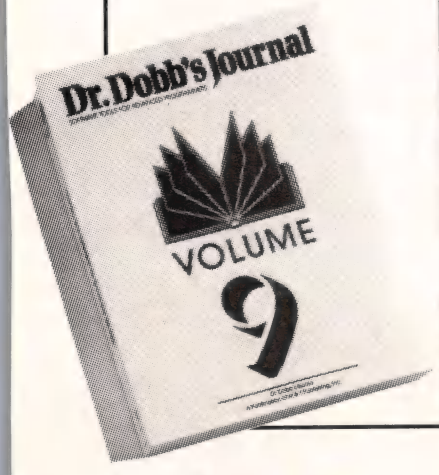

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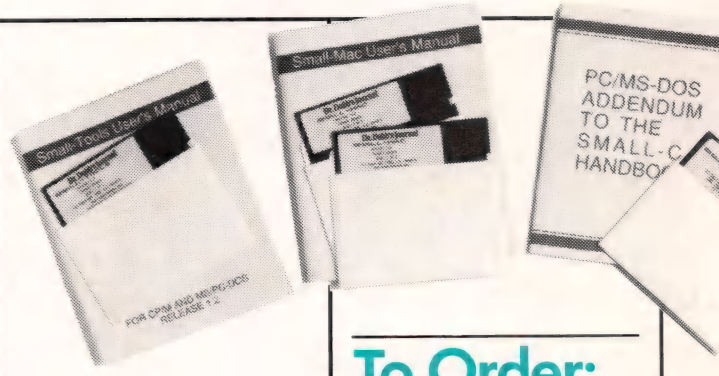

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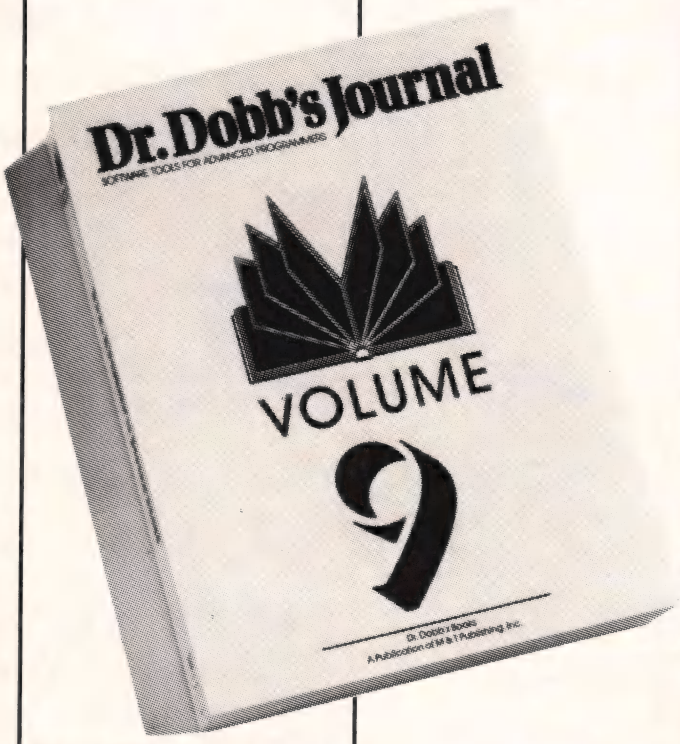

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Running light without overbyte. By year two, *Dr. Dobb's* formula was concocted: tough questions and serious technical issues handled with enthusiasm, wit, and scant reverence for the accepted answers. Source code. Tools for programmers. Respect for tight programming. *Dr. Dobb's Journal* readers shared insights on warping the Intel 8080 into a computer CPU, and *Dr. Dobb's* published a complete operating system for the chip. A motley crop of computers and software products were popping up, and *Dr. Dobb's* investigated: the Heath H-8, the KIM-1, the Alpha Micro, MITS Basic, Poly Basic, and Lawrence Livermore Labs Basic. *Dr. Dobb's* introduced Pilot for microcomputers and published tips on doing string handling, high-speed I/O, and turtle graphics in limited memory.

Bound Volume 3: 1978
Item #015

The roots of Silicon Valley growth. In 1978 Steve Wozniak and other programmers were publishing in *Dr. Dobb's Journal* code that would help them grow multimillion-dollar computer companies. The proposed S-100 bus standard was hashed out in *Dr. Dobb's* pages. *Dr. Dobb's* contributors began to speak more in terms of technique than of specific implementations as the industry began to diversify. Languages covered in depth included SAM76, Pilot, Pascal, and Lisp.

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Item #016

In the midst of the Gold Rush. Three years before IBM would release its PC, a thriving, rough-and-tumble personal computer industry existed. Fortunes had been made and lost, the effective power of the machine multiplied a hundredfold. By 1979 some stability had even emerged; one could speak of the processors that had proven longevity as microcomputer CPUs: the 8080, the Z80, the 6800, and the 6502. *Dr. Dobb's Journal* focused on the best ways to use these processors, with algorithms, tips, and code for 8- to 16-bit conversion, pseudo-random number generation, micro-to-mainframe connections, telecommunications, and networking. And lots of useful code.

Bound Volume 5: 1980

Item #017

The preeminence of CP/M and the rise of C. More than any other magazine, *Dr. Dobb's Journal* was responsible for the spread of CP/M and C on microcomputers. Both of those movements began in 1980. *Dr. Dobb's* all-CP/M issue, including Gary Kildall's history of CP/M, sold out within weeks of publication. This was the year of Ron Cain's original Small C compiler, of a CP/M-oriented C interpreter, CP/M-to-UCSD Pascal file conversion techniques, and of a greater concern in *Dr. Dobb's* with software portability.

Bound Volume 6: 1981

Item #018

The first of Forth. 1981 saw *Dr. Dobb's* first all-Forth issue (now sold out), along with an emphasis on CP/M, C, telecommunications, and new languages. David Cortesi began "Dr. Dobb's Clinic," one of the magazine's most popular features. Highlights included information on PCNET, the Conference Tree, the Electronic Phone Book, Tiny Basic for the 6809, writing your own compiler, and a systems programming language.

Bound Volume 7: 1982

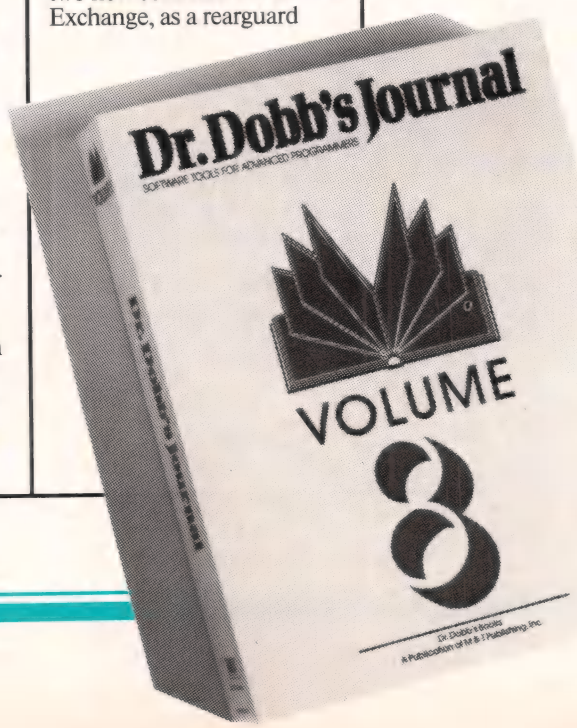
Item #019

Legitimacy. By 1982 IBM had become a player in the personal computer game and was changing the rules. New microprocessors arrived, the first designed specifically to serve as personal computer CPUs. In *Dr. Dobb's Journal* Dave Cortesi published the first serious comparison of MS DOS and CP/M-86. *Dr. Dobb's* started two new columns: the CP/M Exchange, as a rearguard maneuver to ensure that good tools for CP/M programmers would continue to be developed and circulated, and the 16-Bit Software Toolbox to investigate the 8088/86 and other new microprocessors. We published code for the 68000 and Z8000 processors, and looked ahead, in a provocative essay, to fifth-generation computers.

Bound Volume 8: 1983

Item #020

Power tools. Personal computers were proving themselves to be true professional software development tools by 1983, the year in which Jim Hendrix completed his "canonical" version of Small C in *Dr. Dobb's Journal*. *Dr. Dobb's* published more 68000 and 8088 code, and as the memory limitations relaxed, the magazine's commitment to tight code let it shoehorn impossibly large systems into memory. Small C was just one of the major software products published in their entirety in *Dr. Dobb's* pages that year; there were Ed Ream's RED screen editor and a version of the Ada language called Augusta.



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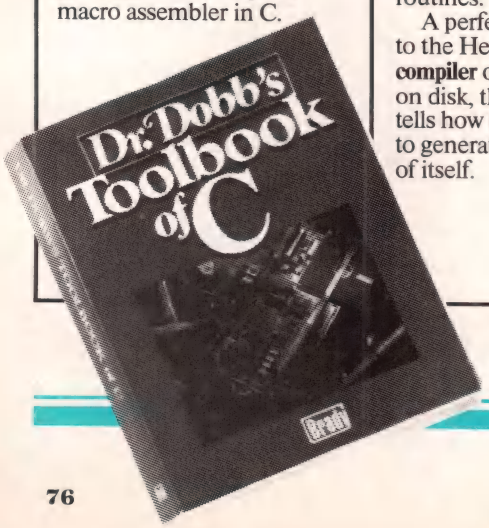

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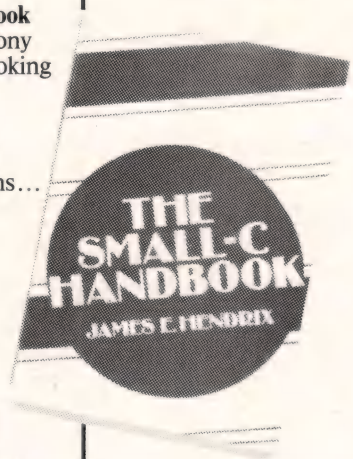

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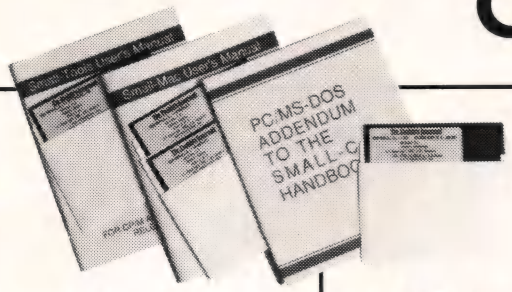

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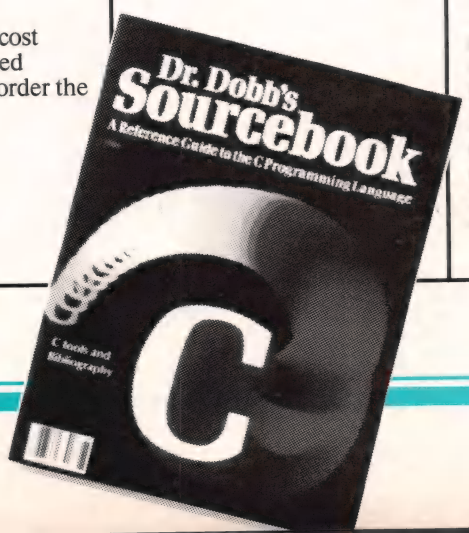

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grep Searches for a pattern defined by a regular expression
Ls Gets a sorted directory
mkdir Creates a directory
mv Renames a file or directory. Moves files to another directory.
p Prints a file, one page at a time
pause Prints a message and waits for a response
printenv Prints all the environment variables
rm Deletes one or more files
rmdir Deletes one or more directories
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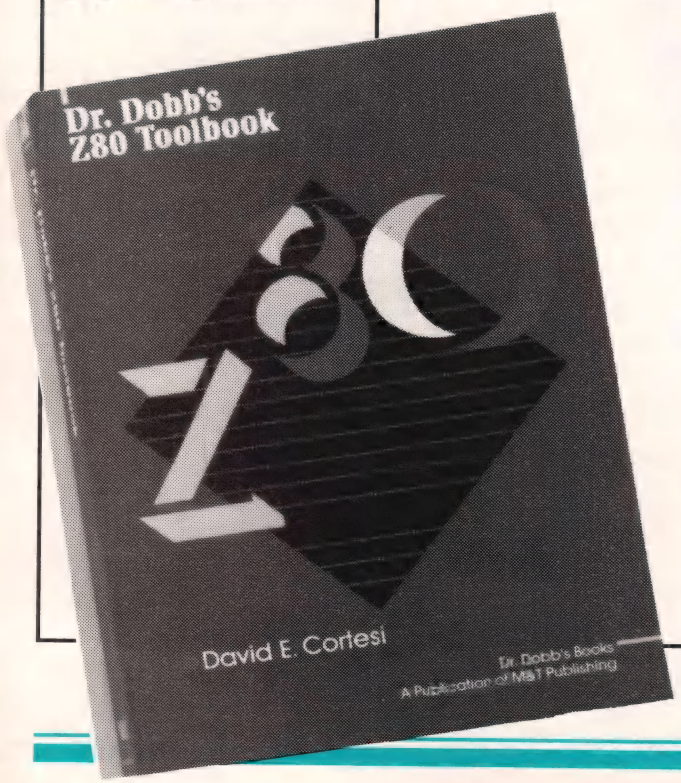

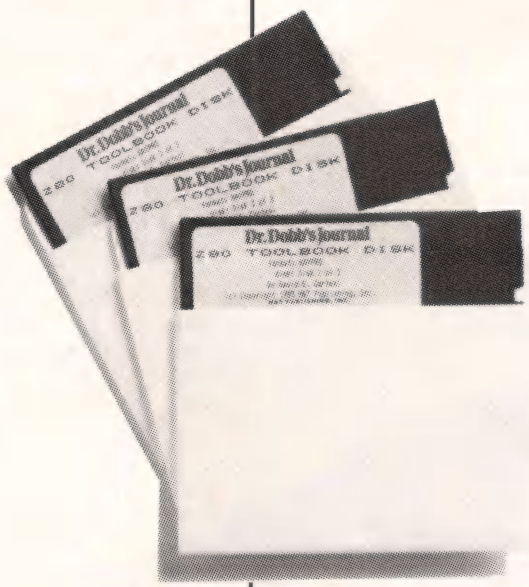

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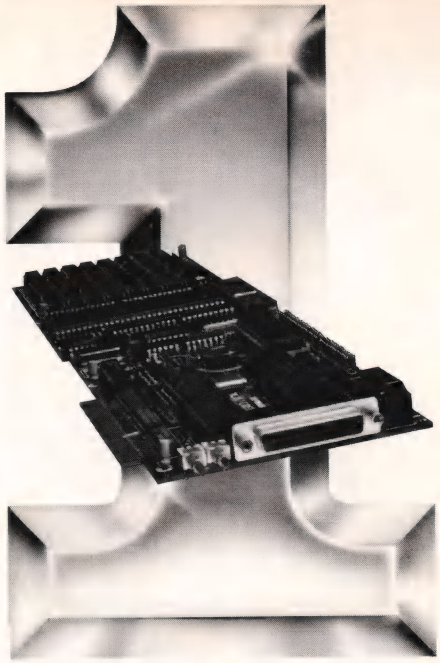
Listing One (Listing continued, text begins on page 22.)

```
388                 if( *lv = malloc(strlen(buf) + 1) )
389                 {
390                         strcpy( *lv++, buf );
391                         *buf = '\0';
392                         Linec++;
393                 }
394                 else
395                         return 1;
396         }
397
398         return( maxcount < 0 );  /* Return 1 if there's more input to get */
399 }
400
401 /*-------------------------------------------------------------------------*/
402
403 char    *fname( num )
404 {
405         /* Return a merge file name for the indicated merge pass.
406          */
407
408         static char     name[ 16 ];
409
410         if( num > MAXTMP )
411         {
412                 fprintf(stderr,"sort: input file too large\n" );
413                 exit(1);
414         }
415
416         sprintf(name, "%smerge.%d", Mdir, num );
417         return( name );
418 }
419
420 /*-------------------------------------------------------------------------*/
421
422 outtext( passnum, more_to_go )
423 {
424         /*      Print out all the strings in the Lines array and free all
425          *      the memory that they use. Output is sent to standard
426          *      output if this is pass 1 and there's no more input
427          *      to process, otherwise output is sent to a merge file.
428          */
429
430         register char   **lv;
431         register FILE   *fp;
432
433         if( passnum == 1  &&  !more_to_go )
434                 fp = stdout;
435
436         else if( !(fp = fopen( fname(passnum), "w" )) )
437         {
438                 fprintf(stderr,"Can't open merge file %s for write\n",
439                                                         fname(passnum));
440                 exit(1);
441         }
442
443         for( lv = Lines ; --Linec >= 0; )
444         {
445                 fputs( *lv,   fp );
446                 free ( *lv++     );
447         }
448
449         fclose( fp );
450 }
451
452 /*-------------------------------------------------------------------------*/
453
454
455 open_mergefiles( nfiles )
456 {
457         /*      Open all the merge files and create the heap. "nfiles"
458          *      merge-files exist and the heap will have that many
459          *      elements in it. The heap is unsorted on exit.
460          */
461
462         HEAP    **hp;
463         int     i;
464
465         for( hp = Heap, i = nfiles;   i > 0;  hp++, --i )
466         {
467                 if( ! (*hp = (HEAP *) malloc(sizeof(HEAP))) )
468                 {
469                         fprintf( stderr, "sort: out of memory!" );
470                         exit( 1 );
471                 }
472
473                 if( !( (*hp)->file = fopen( fname(i), "r")  ))
474                 {
475                         fprintf(stderr,"sort: can't open %s for read",
476                                                         fname(i) );
477                         exit( 1 );
478                 }
479
480                 if( !fgets( (*hp)->string, MAXBUF, (*hp)->file ) )
481                 {
```

(continued on next page)



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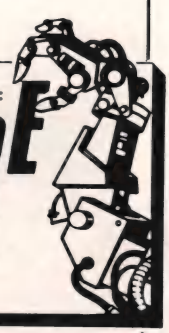

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C CHEST

Listing One **(Listing continued, text begins on page 22.)**

```
482                             fprintf(stderr,"sort: merge file %s is empty",
483                                                             fname(i) );
484                             exit( 1 );
485                     }
486             }
487 }
488
489 /*-------------------------------------------------------------------------*/
490
491 mcmp( hpp1,  hpp2 )
492 HEAP      **hpp1, **hpp2;
493 {
494             /*      Comparison routine for sorting the heap. Is passed
495              *      two pointers to HEAP pointers and compares the
496              *      string fields of these using the same workhorse
497              *      functions used in the initial sorting phase.
498              */
499
500             return  Options ? qcmp1  ((*hpp1)->string, (*hpp2)->string)
501                             : strcmp ((*hpp1)->string, (*hpp2)->string)
502                             ;
503 }
504
505 /*-------------------------------------------------------------------------*/
506
507 reheap( nfiles )
508 {
509             /*      Reheap the Heap, assume that the first element (**Heap)
510              *      is the newly added one.
511              */
512
513             register int    parent, child;
514             HEAP            *tmp;
515
516             for( parent = 0, child = 1; child < nfiles; )
517             {
518                     /*      Find the smaller child. Then if the parent is less
519                      *      than the smaller child, we're done. Otherwise
520                      *      swap the parent and child, and continue the
521                      *      reheaping process with a new parent.
522                      */
523
524                     if( child+1 < nfiles )      /* if child+1 is in the heap */
525                         if( mcmp(&Heap[child], &Heap[child+1]) > 0)
526                             child++;
527
528                     if( mcmp( &Heap[parent], &Heap[child]) <= 0)
529                             break;
530
531                     tmp             = Heap[parent];     /* Exchange             */
532                     Heap[parent] = Heap[child ];
533                     Heap[child ] = tmp;
534
535                     parent = child;
536                     child  = parent << 1;           /*   child = parent * 2 */
537             }
538 }
539
540 /*-------------------------------------------------------------------------*/
541
542 merge( nfiles )
543 int     nfiles;                         /* Number of merge files        */
544 {
545             open_mergefiles( nfiles );
546             ssort( Heap, nfiles, sizeof(Heap[0]), mcmp );
547
548             while( nfiles > 0 )
549             {
550                     pheap( "Merge: top of while loop", nfiles );
551
552                     fputs( (*Heap)->string, stdout );
553
554                     if( !fgets((*Heap)->string, MAXBUF, (*Heap)->file) )
555                     {
556                             /* This input stream is exhausted. Reduce the
557                              * heap size to compensate. Note that Heap+1
558                              * is the same as &Heap[1];
559                              */
560
561                             fclose( (*Heap)->file );
562                             if( --nfiles )
563                                     memcpy(Heap, Heap+1, nfiles * sizeof(HEAP));
564                     }
565
566                     reheap( nfiles );
567             }
568 }
569
570 /*-------------------------------------------------------------------------*/
571
572 adjust_args()
573 {
574             /*      Adjust various default arguments to fix mistakes made
575              *      on the command line. In particular Delim is always 0
576              *      unless either Primary or Secondary was set.
577              *      If a secondary field is specified without a Primary, then
578              *      1 is assumed for the primary. If no Delim is specified
```

```
579         *       then tab (\t) is assumed. "Options" is true if any of
580         *       the options that affect the sort order were specified
581         *       on the command line.
582         */
583
584         if( !(Primary || Secondary) )
585                 Delim = 0;
586         else
587         {
588                 if( !Delim )
589                         Delim = '\t';
590
591                 if( !Primary )
592                         Primary = 1;
593         }
594
595         Options = Noblanks || Numeric || Dictorder || Foldupper
596                                                   || Reverse || Delim;
597 }
598
599 /*-------------------------------------------------------------------------*/
600
601 main(argc, argv)
602 int     argc;
603 char    **argv;
604 {
605         int     numpasses = 0;  /* Number of merge files used           */
606         int     more_input;     /* True if input isn't exhausted        */
607
608         Argc = getargs( argc, argv, Argtab, NUMARGS );
609         Argv = argv;
610         adjust_args();
611
612         do{
613                 more_input = gtext();
614
615                 if( Linec )
616                 {
617                         ssort(Lines, Linec, sizeof(*Lines),
618                                                 Options ? qcmp : argvcmp);
619                         if( Nodups )
620                                 Linec = dedupe(Linec, Lines);
621
622                         outtext( ++numpasses, more_input );
623                 }
624
625         } while(  more_input );
626
627
628         if( numpasses > 1 )             /* merge files were created     */
629         {
630                 fclose( stdin  );       /* Free up default file des-    */
631                 fclose( stdaux );       /* criptors for unused streams  */
632                 fclose( stdprn );       /* so that they can be used for */
633                                         /* merge files.                 */
634                 merge( numpasses );
635
636                 for(; numpasses > 0 ; --numpasses )
637                         unlink( fname(numpasses) );
638         }
639
640         exit(0);
641 }
```

Listing 1 -- stoi.c

End Listing One

Listing Two

```
 1 #include <ctype.h>
 2
 3 int             stoi(instr)
 4 register char   **instr;
 5 {
 6         /*      Convert string to integer updating *instr to point
 7          *      past the number. Return the integer value represented
 8          *      by the string.
 9          */
10
11         register int    num  = 0 ;
12         register char   *str     ;
13         int             sign = 1 ;
14
15         str = *instr;
16
17         if( *str == '-' )
18         {
19                 sign = -1 ;
20                 str++;
21         }
22
23         while( '0' <= *str  &&  *str <= '9' )
24                 num = (num * 10) + (*str++ - '0') ;
25
26         *instr = str;
27         return( num * sign );
28 }
```

End Listings

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LINE GLITCHES

Listing One (Text begins on page 32.)

```
/*
 * short demo program to illustrate Hamming forward error correction
 * code detects and corrects all one bit errors and detects two
 * bit errors in a total transmitted block of 16 bits.
 * eleven bits are message bits, the rest are error checks
 *
 * implementation is oriented toward exposition, not speed or
 * efficiency -- this is not industrial strength code!
 *
 * bit fields not implemented in C/80
 *
 * Joe Marasco, March 1986
 */

#include "fprintf.h"
#define             EOF       -1

#define             B0        1
#define             B1        2
#define             B2        4
#define             B3        8
#define             B4        16
#define             B5        32
#define             B6        64
#define             B7        128
#define             B8        256
#define             B9        512
#define             B10       1024
#define             B11       2048
#define             B12       4096
#define             B13       8192
#define             B14       16384
#define             B15       32768

#define             C1        (B1 + B3 + B5 + B7 + B9 + B11 + B13 + B15)
#define             C2        (B2 + B3 + B6 + B7 + B10 + B11 + B14 + B15)
#define             C3        (B4 + B5 + B6 + B7 + B12 + B13 + B14 + B15)
#define             C4        (B8 + B9 + B10 + B11 + B12 + B13 + B14 + B15)

main()
{
                    int       input[11] ;       /* input message bits        */
register unsigned int         xmit ;            /* transmitted message       */
                    int       recvd[16] ;       /* received message bits*/
register unsigned int         rec ;             /* received message*/
                    int       syndrome ;        /* computed syndrome         */
                    int       recpar    ;       /* parity of rec'd msg       */
                    int       i , ch ;

          for (;;) {

                    printf("input 11 message bits, ^C to quit\n") ;
                    printf("1 2 3 4 5 6 7 8 9 0 1\n") ;

                    i = 0 ;
                    while ( ((ch = getchar()) != EOF) && i<11 )
                              switch(ch) {
                              case '0' :        input[i++] = 0 ;
                                                break ;
                              case '1' :        input[i++] = 1 ;
                                                break ;
                              }
/*
 * anything but a 0 or 1 is ignored
 * check that we have 11 good bits
 */
                    if ( i < 11 ) {
                              printf("not enough valid bits, try again\n") ;
                              continue ;
                    }
/*
 * build the message
 */
                    xmit = 0 ;
                    xmit |= input[0] << 3 ;
                    xmit |= input[1] << 5 ;
                    xmit |= input[2] << 6 ;
                    xmit |= input[3] << 7 ;
                    xmit |= input[4] << 9 ;
                    xmit |= input[5] << 10 ;
                    xmit |= input[6] << 11 ;
                    xmit |= input[7] << 12 ;
                    xmit |= input[8] << 13 ;
                    xmit |= input[9] << 14 ;
                    xmit |= input[10] << 15 ;
/*
 * and the check bits -- even parity
 */
                    xmit |= (parity( C1 & xmit ) << 1) |
                              (parity( C2 & xmit ) << 2) |
                              (parity( C3 & xmit ) << 4) |
                              (parity( C4 & xmit ) << 8)  ;
```

(continued on page 86)

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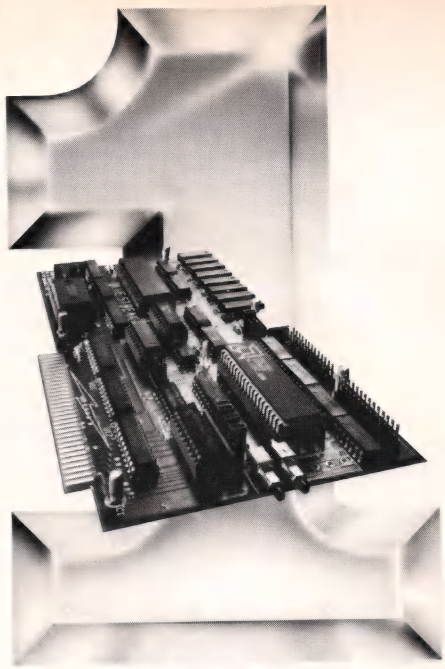

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Listing One (Listing continued, text begins on page 32.)

```
/*
 * and last but not least, make total parity even
 */
                    xmit |= parity( xmit ) ;
/*
 * display it
 */
                    printf("the block sent is                %x \n", xmit ) ;
                    printf("0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5\n") ;
                    for (i=0 ; i<16 ; ++i)
                            printf("%d ", ((xmit>>i) & 01) ) ;
                    printf("\n") ;
                    printf("now input the received block\n") ;
                    printf("0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5\n") ;
/*
 * get the received message
 */
readagain:          i = 0 ;
                    while ( ((ch = getchar()) != EOF) && i<16 )
                            switch(ch) {
                            case '0' :          recvd[i++] = 0 ;
                                                break ;
                            case '1' :          recvd[i++] = 1 ;
                                                break ;
                            }
/*
 * anything but a 0 or 1 is ignored
 * check that we have 16 good bits
 */
                    if ( i < 16 ) {
                            printf("not enough valid bits, try again\n") ;
                            goto readagain ;
                    }
                    for (i=0 , rec=0 ; i<16 ; ++i )
                                    rec |= (recvd[i] << i) ;
                    printf("the block received is            %x \n", rec ) ;
/*
 * compute the syndrome
 */
                    syndrome =   parity( C1 & rec ) |
                                 ( parity( C2 & rec ) << 1 ) |
                                 ( parity( C3 & rec ) << 2 ) |
                                 ( parity( C4 & rec ) << 3 )  ;
/*
 * and the parity bit, which should be zero
 */
                    recpar = parity( rec ) ;
/*
 * decision time
 */
                    if ( syndrome == 0 ) {
                            printf("good message!\n") ;
                            if (recpar) {
                                    printf("with reversed parity bit\n") ;
                                    rec = rec ^ 01 ;
                                    printf("the recovered block is           %x\n",
                                                        rec ) ;
                                    printf("0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5\n") ;
                                    for (i=0 ; i<16 ; ++i)
                                            printf("%d ", ((rec>>i) & 01) ) ;
                                    printf("\n") ;
                            }
                            printf("--------------------------------\n") ;
                    }
                    else {
                            if (!recpar) {
                                    printf("two bit errors, can't fix\n") ;
                                    printf("--------------------------------\n") ;
                            }
                            else {
                                    printf("bad bit in position %d\n",
                                                        syndrome ) ;
                                    rec = rec ^ ( 01 << syndrome ) ;
                                    printf("the recovered block is           %x\n",
                                                                    rec ) ;
                                    printf("0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5\n") ;
                                    for (i=0 ; i<16 ; ++i)
                                            printf("%d ", ((rec>>i) & 01) ) ;
                                    printf("\n--------------------------------\n") ;
                            }
                    }
        }
}
parity( message )
unsigned int message ;
{
/*
 * return 1 if odd parity, 0 if even
 */
        int j , k ;
        for ( j=0 , k=0 ; j<16 ; ++j ) k += ( (message >> j) & 01 ) ;
        return( k & 01 ) ;
}
```

End Listing

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GC LISP 286 Developer - 2 to 15 meg RAM, compiler & interp.		$1195	Call
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AI-Other

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AZTEC C86 - Commercial	PC	$499
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Listing One (Text begins on page 38.)

```
/**
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 *
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 *
 * ABSTRACT:
 *
 *       The function, Transfer_File, implements error-free file transfer using
 *       CompuServe's "B" protocol.
 *
 *       It has been assumed that the start-of-packet sequence, DLE "B", has
 *       been detected and the next byte not received yet is the packet
 *       sequence number (an ASCII digit).
 *
 * ENVIRONMENT: Lattice "C", machine independent.
 *
 * AUTHOR: Steve Wilhite, CREATION DATE: 21-Jul-85
 *
 * REVISION HISTORY:
 *
 *       Steve Wilhite, 17-Jan-86
 *       - included a virtual file interface.
 **/

/*** Feature Test ***/

/* Strip_CR and Strip_LF are mutual exclusive!! */

#define Strip_CR    0         /* If true, strip CR's before writing to disk.
                                 Add CR before sending */
#define Strip_LF    0         /* If true, strip LD's before writing to disk.
                                 Add LF before sending */

/* External Functions */

extern Delay();                         /* Sleep for "n" milliseconds */
extern Put_Char();              /* Write a character to the display */
extern Start_Timer();                   /* Enable the timer for the specified number
                                   seconds */
extern int Timer_Expired();  /* Returns "true" if the timer has expired,
                                   "false" otherwise */
extern int Wants_To_Abort(); /* Returns "true" if the user wants to abort
                                   the file transfer, "false" otherwise */
extern int Read_Modem();     /* Read a character from the comm port.
                                   Returns -1 if no character available */
extern int Write_Modem();    /* Send a character to the comm port. Returns
                                   "true" is successful, "false" otherwise */

/* File I/O Interface */

extern int Create_File(), Open_File(), Close_File();
extern int Read_File(), Write_File();


#define NUL         0x00
#define ETX         0x03
#define ENQ         0x05
#define DLE         0x10
#define XON         0x11
#define XOFF        0x13
#define NAK         0x15

#define True                1
#define False               0
#define Success             -1
#define Failure             0
#define Packet_Size 512
#define Max_Errors  10
#define Max_Time    10
#define Max_Xoff_Time       10
#define WACK                ';'             /* wait acknowledge */

/* Sender actions */

#define S_Send_Packet       0
#define S_Get_DLE   1
#define S_Get_Num   2
#define S_Get_Seq   3
#define S_Get_Data  4
#define S_Get_Checksum      5
#define S_Timed_Out 6
#define S_Send_NAK  7
#define S_Send_ACK  8

/* Receiver actions */

#define R_Get_DLE   0
#define R_Get_B             1
#define R_Get_Seq   2
#define R_Get_Data  3
#define R_Get_Checksum      4
```

(continued on page 92)

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Listing One (Listing continued, text begins on page 38.)

```
#define R_Send_NAK 5
#define R_Send_ACK 6

static int
    Ch,
    Checksum,
    Seq_Num,
    R_Size,                                    /* Size of receiver buffer */
    XOFF_Flag,
    Seen_ETX,
    Seen_ENQ;

static char
    S_Buffer[Packet_Size],          /* Sender buffer */
    R_Buffer[Packet_Size];          /* Receiver buffer */


static Put_Msg(Text)
    char *Text;
    {
    while (*Text != 0)
         Put_Char(*Text++);

    Put_Char('\015');
    Put_Char('\012');
    }


static Send_Byte(Ch)
    int Ch;
    {
    int TCh;

    /* Listen for XOFF from the network */

    Start_Timer(Max_Xoff_Time);
    do
         {
         while ((TCh = Read_Modem()) >= 0)
             if (TCh == XON)
                  XOFF_Flag = False;
             else if (TCh == XOFF)
                  {
                  XOFF_Flag = True;
                  Start_Timer(Max_Xoff_Time);
                  }
         }
    while (XOFF_Flag && !Timer_Expired());

    while (!Write_Modem(Ch));
    }


static Send_Masked_Byte(Ch)
    int Ch;
    {
    /* Mask any protocol or flow characters */

    if (Ch == NUL || Ch == ETX || Ch == ENQ || Ch == DLE || Ch == NAK || Ch == XON || Ch == XOFF)
         {
         Send_Byte(DLE);
         Send_Byte(Ch + '@');
         }
    else
         Send_Byte(Ch);
    }


static Send_ACK()
    {
    Send_Byte(DLE);
    Send_Byte(Seq_Num + '0');
    }


 static Read_Byte()
     {
     if ((Ch = Read_Modem()) < 0)
          {
          Start_Timer(Max_Time);

          do
              {
              if (Timer_Expired())
                   return Failure;
              }
          while ((Ch = Read_Modem()) < 0);
          }

     return Success;
     }


 static Read_Masked_Byte()
     {
```

(continued on page 94)

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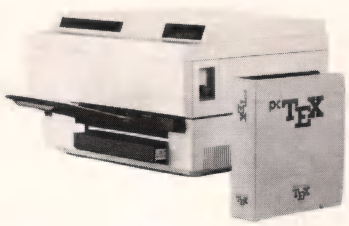

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Circle **no. 76** on reader service card.

B PROTOCOL

Listing One

(Listing continued, text begins on page 38.)

```
    Seen_ETX = False;
    Seen_ENQ = False;

    if (Read_Byte() == Failure)
          return Failure;

    if (Ch == DLE)
          {
          if (Read_Byte() == Failure)
              return Failure;

          Ch &= 0x1F;
          }
    else if (Ch == ETX)
          Seen_ETX = True;
    else if (Ch == ENQ)
          Seen_ENQ = True;

    return Success;
    }


static Do_Checksum(Ch)
    int Ch;
    {
    Checksum <<= 1;

    if (Checksum > 255)
          Checksum = (Checksum & 0xFF) + 1;

    Checksum += Ch & 0xFF;

    if (Checksum > 255)
          Checksum = (Checksum & 0xFF) + 1;
    }


static int Read_Packet(Action)
/**
 * Function:
 *       Receive a packet from the host.
 *
 * Inputs:
 *       Action -- the starting action
 *
 * Outputs:
 *       R_Buffer -- contains the packet just received
 *       R_Size -- length of the packet
 *
 * Returns:
 *       success/failure
 **/
    int Action;
    {
    int
          Errors,
          Next_Seq;

    Errors = 0;

    while (Errors < Max_Errors)
          switch (Action)
              {
              case R_Get_DLE:
                    if (Read_Byte() == Failure)
                        Action = R_Send_NAK;
                    else if (Ch == DLE)
                        Action = R_Get_B;
                    else if (Ch == ENQ)
                        Action = R_Send_ACK;

                    break;

              case R_Get_B:
                    if (Read_Byte() == Failure)
                        Action = R_Send_NAK;
                    else if (Ch == 'B')
                        Action = R_Get_Seq;
                    else
                        Action = R_Get_DLE;

                    break;

              case R_Get_Seq:
                    if (Read_Byte() == Failure)
                        Action = R_Send_NAK;
                    else
                        {
                        Checksum = 0;
                        Next_Seq = Ch - '0';
                        Do_Checksum(Ch);
                        R_Size = 0;
                        Action = R_Get_Data;
                        }
```

```
                break;

            case R_Get_Data:
                if (Read_Masked_Byte() == Failure)
                    Action = R_Send_NAK;
                else if (Seen_ETX)
                    Action = R_Get_Checksum;
                else if (Seen_ENQ)
                    Action = R_Send_ACK;
                else if (R_Size == Packet_Size)
                    Action = R_Send_NAK;
                else
                    {
                    R_Buffer[R_Size++] = Ch;
                    Do_Checksum(Ch);
                    }

                break;

            case R_Get_Checksum:
                Do_Checksum(ETX);

                if (Read_Masked_Byte() == Failure)
                    Action = R_Send_NAK;
                else if (Checksum != Ch)
                    Action = R_Send_NAK;
                else if (Next_Seq == Seq_Num)
                    Action = R_Send_ACK;    /* Ignore duplicate packet */
                else if (Next_Seq != (Seq_Num + 1) % 10)
                    Action = R_Send_NAK;
                else
                    {
                    Seq_Num = Next_Seq;

                    return Success;
                    }

                break;

            case R_Send_NAK:
                Put_Char('-');
                Errors++;
                Send_Byte(NAK);
                Action = R_Get_DLE;
                break;

            case R_Send_ACK:
                Send_ACK();
                Action = R_Get_DLE;
                break;
            }

    return Failure;
    }

static int Send_Packet(Size)
/**
 * Function:
 *      Send the specified packet to the host.
 *
 * Inputs:
 *      Size -- length of the packet
 *      S_Buffer -- the packet to send
 *
 * Outputs:
 *
 * Returns:
 *      success/failure
 **/
    int Size;
    {
    int
        Action,
        Next_Seq,
        RCV_Num,
        I,
        Errors;

    Next_Seq = (Seq_Num + 1) % 10;
    Errors = 0;
    Action = S_Send_Packet;

    while (Errors < Max_Errors)
        switch (Action)
            {
            case S_Send_Packet:
                Checksum = 0;
                Send_Byte(DLE);
                Send_Byte('B');
                Send_Byte(Next_Seq + '0');
                Do_Checksum(Next_Seq + '0');

                for (I = 0; I < Size; I++)
                    {
                    Send_Masked_Byte(S_Buffer[I]);
                    Do_Checksum(S_Buffer[I]);
                    }

                Send_Byte(ETX);
                Do_Checksum(ETX);
                Send_Masked_Byte(Checksum);
```

(continued on next page)

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Circle **no. 223** on reader service card.

Listing One (Listing continued, text begins on page 38.)

```
        Action = S_Get_DLE;
        break;

    case S_Get_DLE:
        if (Read_Byte() == Failure)
            Action = S_Timed_Out;
        else if (Ch == DLE)
            Action = S_Get_Num;
        else if (Ch == ENQ)
            Action = S_Send_ACK;
        else if (Ch == NAK)
            {
            Errors++;
            Action = S_Send_Packet;
            }

        break;

    case S_Get_Num:
        if (Read_Byte() == Failure)
            Action = S_Timed_Out;
        else if (Ch >= '0' && Ch <= '9')
            {
            if (Ch == Seq_Num + '0')
                Action = S_Get_DLE; /* Ignore duplicate ACK */
            else if (Ch == Next_Seq + '0')
                {
                /* Correct sequence number */

                Seq_Num = Next_Seq;
                return Success;
                }
            else if (Errors == 0)
                Action = S_Send_Packet;
            else
                Action = S_Get_DLE;
            }
        else if (Ch == WACK)
            {
            Delay(5000);    /* Sleep for 5 seconds */
            Action = S_Get_DLE;
            }
        else if (Ch == 'B')
            Action = S_Get_Seq;
        else

            Action = S_Get_DLE;

        break;

    case S_Get_Seq:
        /**
         * Start of a "B" protocol packet. The only packet that makes
         * any sense here is a failure packet.
         **/

        if (Read_Byte() == Failure)
            Action = S_Send_NAK;
        else
            {
            Checksum = 0;
            RCV_Num = Ch - '0';
            Do_Checksum(Ch);
            I = 0;
            Action = S_Get_Data;
            }

        break;

    case S_Get_Data:
        if (Read_Masked_Byte() == Failure)
            Action = S_Send_NAK;
        else if (Seen_ETX)
            Action = S_Get_Checksum;
        else if (Seen_ENQ)
            Action = S_Send_ACK;
        else if (I == Packet_Size)
            Action = S_Send_NAK;
        else
            {
            R_Buffer[I++] = Ch;
            Do_Checksum(Ch);
            }

        break;

    case S_Get_Checksum:
        Do_Checksum(ETX);

        if (Read_Masked_Byte() == Failure)
            Action = S_Send_NAK;
        else if (Checksum != Ch)
            Action = S_Send_NAK;
        else if (RCV_Num != (Next_Seq + 1) % 10)
            Action = S_Send_NAK;
        else
            {
```

```
                        /**
                         * Assume the packet is failure packet. It makes no
                         * difference since any other type of packet would be
                         * invalid anyway. Return failure to caller.
                         **/

                        Errors = Max_Errors;
                        }

                    break;

                case S_Timed_Out:
                    Errors++;
                    Action = S_Get_DLE;
                    break;

                case S_Send_NAK:
                    Put_Char('-');
                    Errors++;
                    Send_Byte(NAK);
                    Action = S_Get_DLE;
                    break;

                case S_Send_ACK:
                    Send_ACK();
                    Action = S_Get_DLE;
                    break;
                }

        return Failure;
        }

static Send_Failure(Code)
/**
 * Function:
 *      Send a failure packet to the host.
 *
 * Inputs:
 *      Code -- failure code
 *
 * Outputs:
 *
 * Returns:
 **/
    char Code;
    {
    S_Buffer[0] = 'F';
    S_Buffer[1] = Code;
    Send_Packet(2);
    }

static int Receive_File(Name)
/**
 * Function:
 *      Download the specified file from the host.
 *
 * Inputs:
 *      Name -- ptr to the file name string
 *
 * Outputs:
 *
 * Returns:
 *      success/failure
 **/
    char *Name;
    {
    int Data_File;                  /* file descriptor */

    if ((Data_File = Create_File(Name, 0)) == -1)
        {
        Put_Msg("Cannot create file");
        Send_Failure('E');
        return Failure;
        }

    Send_ACK();

    for (;;)
        if (Read_Packet(R_Get_DLE) == Success)
            switch (R_Buffer[0])
                {
                case 'N':           /* Data packet */

                    if (Write_File(Data_File, &R_Buffer[1], R_Size - 1) != R_Size - 1)
                        {
                        /* Disk write error */

                        Put_Msg("Disk write error");
                        Send_Failure('E');
                        Close_File(Data_File);
                        return Failure;
                        }

                    if (Wants_To_Abort())
                        {
                        /* The user wants to kill the transfer */

                        Send_Failure('A');
                        Close_File(Data_File);
                        return Failure;
                        }
```

(continued on next page)

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Listing One (Listing continued, text begins on page 38.)

```
                Send_ACK();
                Put_Char('+');
                break;

            case 'T':           /* Transfer packet */

                if (R_Buffer[1] == 'C') /* Close file */
                    {
                    Send_ACK();
                    Close_File(Data_File);
                    return Success;
                    }
                else
                    {
                    /**
                     * Unexpected "T" packet. Something is rotten on the
                     * other end. Send a failure packet to kill the
                     * transfer cleanly.
                     **/

                    Put_Msg("Unexpected packet type");
                    Send_Failure('E');
                    Close_File(Data_File);
                    return Failure;
                    }

            case 'F':           /* Failure packet */
                Send_ACK();
                Close_File(Data_File);
                return Failure;
            }
    else
        {
        Close_File(Data_File);
        return Failure;
        }
}

static int Send_File(Name)
/**
 * Function:
 *      Send the specified file to the host.
 *
 * Inputs:
 *      Name -- ptr to the file name string
 *
 * Outputs:
 *
 * Returns:
 *      success/failure
 **/
    char *Name;
    {
    int
        Data_File,                          /* file descriptor */
        N;

    if ((Data_File = Open_File(Name, 0)) == -1)
        {
        Put_Msg("Cannot access that file");
        Send_Failure('E');
        return Failure;
        }

    do
        {
        S_Buffer[0] = 'N';
        N = Read_File(Data_File, &S_Buffer[1], Packet_Size - 1);

        if (N > 0)
            {
            if (Send_Packet(N + 1) == Failure)
                {
                Close_File(Data_File);
                return Failure;
                }

            if (Wants_To_Abort())
                {
                Send_Failure('A');
                Close_File(Data_File);
                return Failure;
                }

            Put_Char('+');
            }
        }
    while (N > 0);

    if (N == 0)                             /* end of file */
        {
        Close_File(Data_File);
        S_Buffer[0] = 'T';
        S_Buffer[1] = 'C';
        return Send_Packet(2);
        }
```

```
    else
        {
        Put_Msg("Disk read error");
        Send_Failure('E');
        return Failure;
        }
    }

int Transfer_File()
/**
 * Function:
 *      Transfer a file from/to the micro to/from the host.
 *
 * Inputs:
 *
 * Outputs:
 *
 * Returns:
 *      success/failure
 **/
    {
    int I, N;
    char Name[64];                      /* holds the file name */

    XOFF_Flag = False;
    Seq_Num = 0;

    if (Read_Packet(R_Get_Seq) == Success)
        {
        if (R_Buffer[0] == 'T')                 /* transfer packet */
            {
            /* Check the direction */

            if (R_Buffer[1] != 'D' && R_Buffer[1] != 'U')
                {
                Send_Failure('N'); /* not implemented */
                return Failure;
                }

            /* Check the file type */

            if (R_Buffer[2] != 'A' && R_Buffer[2] != 'B')
                {
                Send_Failure('N');
                return Failure;
                }

            /* Collect the file name */

            N = R_Size - 3 > 63 ? 63 : R_Size - 3;

            for (I = 0; I < N; I++)
                Name[I] = R_Buffer[I + 3];

            Name[I] = 0;

            /* Do the transfer */

            if (R_Buffer[1] == 'U')
                return Send_File(Name);
            else
                return Receive_File(Name);
            }
        else
            {
            Send_Failure('E');                  /* wrong type of packet */
            return Failure;
            }
        }
    else
        return Failure;
    }
```

End Listing One

Listing Two

```
        title   Keyboard Driver
        include \lc\dos.mac
        pseg

        public  Read_Keyboard

Read_Keyboard proc
;++
; Function:
;       Read a "raw" character from the keyboard.
;
; Inputs: none
;
; Outputs: none
;
; Returns:
;       -1 if no character is available; otherwise a 16-bit code.
;       If the high byte is zero, then the low byte is an ASCII character,
;       else the low byte is an "extended" character (scan code).
;--
        mov     AH,1
```

(continued on next page)

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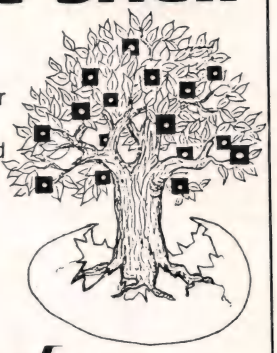

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Listing Two (Listing continued, text begins on page 38.)

```
        int     16H                     ; Scan the keyboard
        jz      Read_Keyboard_1         ; No character available
        mov     AH,0                    ; Yes
        int     16H                     ; Read keyboard
        cmp     AL,0                    ; Extended character
        je      Read_Keyboard_2         ; Yes
        mov     AH,0                    ; No, normal character
        ret

Read_Keyboard_1:
        mov     AX,-1                   ; Denote "no character available"
        ret

Read_Keyboard_2:                        ; Extended character
        mov     AL,AH
        mov     AH,01H                  ; Set the "function key" flags
        ret

Read_Keyboard endp

        endps
        end
```

End Listing Two

Listing Three

```
/*
 * This program emulates a dump terminal with file transfer support using
 * CompuServe's B-Protocol.  This program is just a sample of how to interface
 * the BP module (BP.C) with the rest of the terminal emulator.
 */

#define IBM_PC      1

extern int Transfer_File();  /* Transfer a file using the "B" protocol */

extern int Read_Keyboard();  /* Get a "raw" character from the keyboard */

extern Open_Modem();                /* Initialize the comm port */
extern int Read_Modem();     /* Read a character from the comm port */
```

(continued on page 102)

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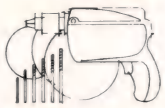

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Listing Three **(Listing continued, text begins on page 38.)**

```
extern int Write_Modem();     /* Send a character to the comm port */
extern Close_Modem();                 /* Release the comm port */

#define True  1
#define False  0

#define Baud_300    1         /* Baud rate codes used by Open_Modem */
#define Baud_450    2
#define Baud_1200   3
#define Baud_1800   4
#define Baud_2400   5
#define Baud_4800   6
#define Baud_9600   7

#ifdef IBM_PC                         /* for IBM style keyboards */
#define Exit_Key  0x012D      /* Alt-X */
#else
#define Exit_Key  0x001D      /* control-] */
#endif

#define Is_Function_Key(C)   ((C) > 127)

#define ENQ  0x05
#define DLE  0x10
#define ESC  0x1B

/*
 * We only support the B-protocol file transfer. No other VIDTEX features.
 */
static char VIDTEX_Response[] = "#DTE,PB,DT\015";

static int
    Old_Break_State,
    I,
    Ch,                               /* 16-bit "raw" character */
    Want_7_Bit,                       /* true if we want to ignore the parity bit */
    ESC_Seq_State;            /* Escape sequence state variable */


int Wants_To_Abort()
{
    return Read_Keyboard() == ESC;
}

main()
{
    char *cp;

    Want_7_Bit = True;
    ESC_Seq_State = 0;

#ifdef MSDOS
    Old_Break_State = Get_Break();
    Set_Break(0);
#endif

    Open_Modem(0, Baud_1200, False);
    puts("[ Terminal Mode ]");
    Ch = Read_Keyboard();

    while (Ch != Exit_Key)
          {
          if (Ch > 0)
              {
              if (Is_Function_Key(Ch))
                    {
                    /* Here to process any local function keys. */
                    }
              else
                    Write_Modem(Ch & 0x7F);
              }

          if ((Ch = Read_Modem()) >= 0)
              {
              if (Want_7_Bit) Ch &= 0x7F;

              switch (ESC_Seq_State)
                    {

                     case 0:
                         switch (Ch)
                               {
                               case ESC:
                                   ESC_Seq_State = 1;
                                   break;

                               case ENQ:
                                   /* Enquiry -- send ACK for packet 0 */

                                   Write_Modem(DLE);
                                   Write_Modem('0');
                                   break;

                               case DLE:
                                   ESC_Seq_State = 2;
                                   break;
```

```
                default:
                    Put_Char(Ch);
                }

            break;

        case 1:
            /* ESC -- process any escape sequences here */

            switch (Ch)
                {
                case 'I':
                    /*
                     * Reply to the VIDTEX "ESC I" identify sequence
                     */
                    cp = VIDTEX_Response;
                    while (*cp != 0) Write_Modem(*cp++);
                    ESC_Seq_State = 0;
                    break;

                default:
                    Put_Char(ESC);
                    Put_Char(Ch);
                    ESC_Seq_State = 0;
                }

            break;

        case 2:
            /* DLE */

            if (Ch == 'B')
                {
                /* Start of "B" protocol packet. Go into protocol
                 * mode and transfer the file as requested.
                 */

                if (!Transfer_File()) puts("Transfer failed!");
                }
            else
                {
                Put_Char(DLE);
                Put_Char(Ch);
                }

            ESC_Seq_State = 0;
        }
}
```

(continued on next page)

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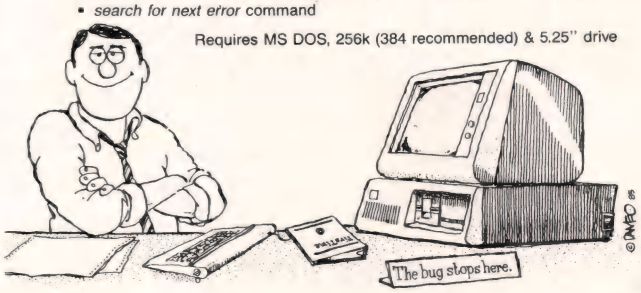

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Listing Three (Listing continued, text begins on page 38.)

```
            Ch = Read_Keyboard();
            }

        Close_Modem();

#ifdef MSDOS
    Set_Break(Old_Break_State);
#endif
}
```

End Listing Three

Listing Four

```
            title     Screen
            include   \lc\dos.mac

Video               equ       10H               ; IBM BIOS call
TTY_Write equ       14

            pseg

            public    Put_Char

Put_Char proc
;++
; Function:
;           Write a character to the screen in "normal" TTY-style output.
;
; Inputs:
;           4[BP]     - the character to write
;
; Outputs: none
;
; Returns: nothing
;--
            push      BP
            mov       BP,SP
            mov       AL,4[BP]          ; Character to write
            mov       BH,0                        ; Current page
            mov       AH,TTY_Write
            int       Video
            pop       BP
            ret
Put_Char endp

            endps
            end
```

End Listing Four

(Listings to be continued next month.)

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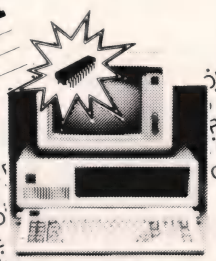

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16-BIT

Listing One (Text begins on page 112.)

```
        mov     dx,seg fname    ; open a file for I/O
        mov     ds,dx           ; DS:DX = ASCIIZ filespec
        mov     dx,offset fname ; function 3DH = open,
        mov     ax,3d02h        ; use mode 2 (read/write)
        int     21h
        jc      error           ; jump if open failed
        mov     my_file,ax      ; save handle for file

        .
        .                       ; further file
        .                       ; processing here
        .

                                ; now use DUP and CLOSE
                                ; to update the directory...
        mov     bx,my_file      ; get handle for file
        mov     ah,45h          ; function 45H = DUP handle,
        int     21h
        jc      error           ; jump if DUP failed
        mov     bx,ax           ; now close the DUP'd handle
        mov     ah,3eh          ; function 3EH = close file
        int     21h             ; transfer to MS-DOS
        jc      error           ; jump if close failed
                                ; otherwise directory is
                                ; updated, continue processing
        .
        .
error:  .
        .
        .

my_file dw      0               ; handle from previous "open"

fname   db      'MYFILE.DAT',0  ; ASCIIZ filespec
```

End Listing One

Listing Two

```
page 60, 120
title Redirected I/O example

;
; REDIRECT.ASM --- An illustration of
; I/O redirection under MS-DOS 2.x or 3.x
;
; Copyright (C) 1985 by Jerry Jankura
; Created:   6 November 1985
; Modified:  9 November 1985
;
; Abstract: This routine demonstrates redirection of I/O
; from the console to a line printer.  The method may be
; used to redirect I/O from any device to any other device.
; Requires Microsoft MS-DOS 2.X or 3.X, or DRI Concurrent
; DOS version 4.1.
;

STD_IN          EQU     0       ; Standard input handle
STD_OUT         EQU     1       ; Standard output handle
STD_ERR         EQU     2       ; Standare error handle
STD_AUX         EQU     3       ; Standard Auxiliary handle
STD_LST         EQU     4       ; Standard printer handle

C_WRITESTR      EQU     9       ; Write string to STD_OUT

F_DUP           EQU     45H     ; Duplicate handle
F_CDUP          EQU     46H     ; Force duplicate handle
F_CLOSE         EQU     3EH     ; Close file handle
F_WRITE         EQU     40H     ; Write to file or dev

P_TERM          EQU     4CH     ; Terminate a program

MS_DOS          EQU     21H     ; MS-DOS service request

CR              EQU     0DH     ; Carriage return
LF              EQU     0AH     ; Line feed

datasg          segment para    'data'


msg1            db      CR, LF, 'Redirected I/O example....'
                db      CR, LF
                db      CR, LF, 'This example was written using the'
                db      CR, LF, 'File I/O system services, with the'
                db      CR, LF, 'file handle being set to STD_OUT.'
                db      CR, LF, 'STD_OUT normally defaults to the'
                db      CR, LF, 'video screen, so you are reading'
                db      CR, LF, 'this message on the screen.'
                db      CR, LF

msg2            db      CR, LF, 'However, we may direct STD_OUT to'
                db      CR, LF, 'another device, such as the printer.'
                db      CR, LF, 'This message is still written to'
                db      CR, LF, 'STD-OUT, but is appears at the printer.'
                db      CR, LF, 'Again, the operating system provides'
                db      CR, LF, 'the facility to allow one file to mimic'
                db      CR, LF, 'and track another.  The Command processor'
                db      CR, LF, 'normally implements this redirection'
                db      CR, LF, 'of standard devices.'
                db      CR, LF

msg3            db      CR, LF, 'This message is written on the'
                db      CR, LF, 'Video screen, demonstrating that'
                db      CR, LF, 'a message may be redirected to the'
                db      CR, LF, 'normal STD_OUT device in the same'
                db      CR, LF, 'manner that was used to redirect'
                db      CR, LF, 'it to the printer.'
                db      CR, LF
```

```
                db      CR, LF, 'Note also that the initialized data is'
                db      CR, LF, 'stored in the data segment, rather'
                db      CR, LF, 'than in the code segment.'
                db      CR, LF
                db      CR, LF, 'Also, the messages are written using'
                db      CR, LF, 'block I/O, so a minimum number of DOS'
                db      CR, LF, 'system services are requested.'

msg4            db      0

dup_handle      dw      ?
orig_handle     dw      ?

datasg          ends

stacksg         segment para stack 'stack'

mystack         db      512 dup (?)

stacksg         ends

code            segment para 'code'

assume          cs: code
assume          ds: datasg
assume          ss: stacksg
assume          es: nothing

test_redirect   proc    far

; Initialize stack pointer and data segment register
; to the correct values.  The stack pointer is set
; to the top of the stack segment.  The data segment
; is set to the segment of the first variable.  Note
; that at this point in time, the DS register does
; not point to the PSP.

                mov     sp, 513 ; set up user stack
                mov     ax, seg msg1
                mov     ds, ax

; First, write a sign-on message to the screen.  We
; will attempt to write this message to the standard
; output device.

;       ah:     INT 21H function id.
;       bx:     file handle
;       cx:     # of bytes to transfer
;       DS:dx   points to message

                mov     ah, F_WRITE
                mov     dx, offset msg1
                mov     bx, STD_OUT
                mov     cx, msg2-msg1
                int     MS_DOS

; Now, we wish to redirect the output to the
; printer.  Before we force the redirection,
; we must make a copy of the standard output
; file handle and store it in the field
; orig_handle.

                mov     bx, STD_OUT
                mov     ah, F_DUP
                int     MS_DOS
                mov     word ptr orig_handle, ax
                mov     bx, STD_LST
                mov     ah, F_DUP
                int     MS_DOS
                mov     word ptr dup_handle, ax

; Then, the STD_LST handle is set to track
; the STD_OUT file.

                mov     bx, ax
                mov     cx, STD_OUT
                mov     ah, F_CDUP
                int     MS_DOS

; Let's write a message out and try it.
; Note that we are still writing information to
; the STD_OUT device.

                mov     ah, F_WRITE
                mov     bx, STD_OUT
                mov     cx, msg3-msg2
                mov     dx, offset msg2
                int     MS_DOS

; Now, let's clean up and return everything
; back to its original condition.

                mov     bx, word ptr dup_handle
                mov     ah, F_CLOSE
                int     MS_DOS

                mov     bx, word ptr orig_handle
                mov     cx, STD_OUT
                mov     ah, F_CDUP
                int     MS_DOS

                mov     ah, F_WRITE
                mov     bx, STD_OUT
                mov     cx, msg4-msg3
                mov     dx, offset msg3
                int     MS_DOS

                mov     ah, P_TERM
                int     MS_DOS

test_redirect   endp

code            ends

                end     test_redirect
```

End Listings

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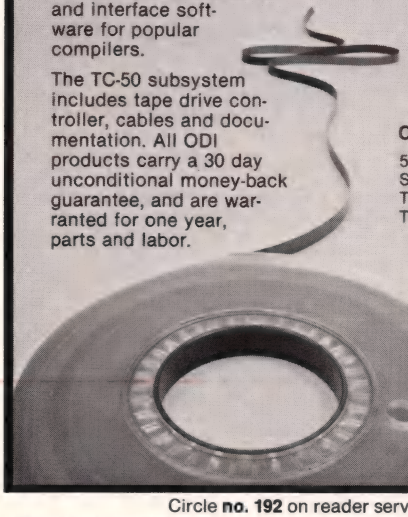

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Listing One (Text begins on page 116.)

```
{------------------ Constants and Data Types Needed ----------}
CONST MAX_SWITCH = 3;
      MAX_ELEMENTS = 100;
      MAX_BIN = 30;
      MAX_BIN_PLUS_ONE = 31;

TYPE Histogram_Rec =

     RECORD
        Num_Elements : 1..MAX_ELEMENTS;
        Switch : 1..MAX_SWITCH;
        Num_Bins : 1..MAX_BIN_PLUS_ONE;
        Count : ARRAY [1..MAX_BIN] OF INTEGER;  { For output only }
        CASE INTEGER OF
          1 : (Real_Array : ARRAY [1..MAX_ELEMENTS] OF REAL;
               Real_Bins  : ARRAY [1..MAX_BIN_PLUS_ONE] OF REAL);
          2 : (String_Array : ARRAY [1..MAX_ELEMENTS] OF STRING[80];
               First_Char, Last_Char : INTEGER;
               String_Bins  : ARRAY [1..MAX_BIN_PLUS_ONE] OF STRING[20]);
{ ---------------- More types here ------------------------------}
{       3 : (Intg_Array : ARRAY [1..MAX_ELEMENTS] OF INTEGER;       }
{            Intg_Bins  : ARRAY [1..MAX_BIN_PLUS_ONE] OF INTEGER);  }
{       4 : (Char_Array : ARRAY [1..MAX_ELEMENTS] OF CHAR;          }
{            Char_Bins  : ARRAY [1..MAX_BIN_PLUS_ONE] OF CHAR);     }

     END;


PROCEDURE Count_Histogram(VAR Histogram : Histogram_Rec);
{ Pseudo-overloaded histogram counting procedure }

VAR I, J :INTEGER;
    Found : BOOLEAN;

PROCEDURE Real_Histogram;
{ Local procedure to count histogram frequency for an array of reals }

BEGIN
    WITH Histogram DO BEGIN
        FOR I := 1 TO Num_Elements DO BEGIN { main loop }
            { Is element within bin ranges ? }
            IF (Real_Array[I] >= Real_Bins[1]) AND
               (Real_Array[I] < Real_Bins[Num_Bins])
            THEN BEGIN  { Locate corresponding bin }
                J := 1; Found := FALSE;
                WHILE (J < Num_Bins) AND (NOT Found) DO
                    IF (Real_Array[I] >= Real_Bins[J]) AND
                       (Real_Array[I] < Real_Bins[J+1])
                       THEN Found := TRUE
                       ELSE J := J + 1;
                { END WHILE }
                Count[J] := Count[J] + 1;
            END; { IF }
        END; { FOR I }
    END; { WITH }
END; { Real_Histogram }


PROCEDURE String_Histogram;
{ Procedure to count histogram frequency for an array of strings }

VAR Strr  : STRING[20];
    Copy_String : STRING[80];

BEGIN
    WITH Histogram DO BEGIN
        FOR I := 1 TO Num_Elements DO BEGIN  { main loop }
            Copy_String := String_Array[I];
            Strr := ''; { initialize Strr }
            { Extract portion of string for comparison }
            FOR J := First_Char TO Last_Char DO
                Strr := Strr + Copy_String[J];

            { Is element within bin ranges ? }
            IF (Strr >= String_Bins[1]) AND
               (Strr < String_Bins[Num_Bins])
            THEN BEGIN
                J := 1; Found := FALSE;
                WHILE (J < Num_Bins) AND (NOT Found) DO
                    IF (Strr >= String_Bins[J]) AND
                       (Strr < String_Bins[J+1])
                       THEN Found := TRUE
                       ELSE J := J + 1;
                { END WHILE }
                Count[J] := Count[J] + 1;
            END; { IF }
        END; { FOR I }
    END; { WITH }

END; { String_Histogram }

BEGIN
    { Initialize keys }
    FOR I := 1 TO MAX_BIN DO
        Histogram.Count[I] := 0;

    CASE Histogram.Switch OF
        1 : Real_Histogram;  { Do histogram count for reals }
        2 : String_Histogram; { Do histogram count for strings }
    END; { CASE }
END; {  Count_Histogram }
```

End Listing One

Listing Two

```
{------------------ Constants and Data Types Needed ----------}
TYPE Complex = RECORD
                 Is_Polar : BOOLEAN;
                 CASE BOOLEAN OF
                     { Polar coordinates }
                      TRUE  : (Modulus, Angle : REAL);
                      { Rectangular coordinates }
                      FALSE : (Xcoord, YCoord : REAL);
               END;


PROCEDURE Add(A, B : Complex; { input }
              VAR C : Complex { ouput });
{ Procedure to add two complex numbers taking into account }
{ their dual presentation.          }
{ local rectangular coordinates }
VAR X1, X2, X3, Y1, Y2, Y3 : REAL;

PROCEDURE Get_Coordinates(P : Complex; { input }
                          X, Y : REAL { output });
{ Local procedure to obtain rectangular coordinates }
BEGIN
 WITH P DO BEGIN
    IF P.Is_Polar
    THEN BEGIN
        X := Modulus * COS(Angle);
        Y := Modulus * SIN(Angle)
    END
    ELSE BEGIN
        X := Xcoord;
        Y := Ycoord
    END; { IF }
 END; { WITH }
END; { Get_Coordinates }

BEGIN
    { Get rectangular coordinates of A and B }
    Get_Coordinates(A, X1, Y1);
    Get_Coordinates(B, X2, Y2);

    { Add rectangular components }
    X3 := X1 + X2; Y3 := Y1 + Y2;

    WITH C DO BEGIN
        IF Is_Polar
        THEN BEGIN
            Modulus := SQRT(X3*X3 + Y3*Y3);
            Angle := ArcTan(Y3/X3)
        END
        ELSE BEGIN
            Xcoord := X3;
            Ycoord := Y3
        END; { IF }
    END; { WITH }
END; { Add }
```

End Listing Two

Listing Three

```
{-------------- Constants and Data Types Needed --------------}
CONST MAX_HEIGHT = 100;

TYPE

     Complex = RECORD Reel, Imaginary : REAL; END;

     Stack_Rec =
        RECORD
            Switch : INTEGER;
            CASE INTEGER OF
                0 : (Integer_type : INTEGER);
                1 : (Real_type : REAL);
                2 : (String_type : STRING[80]);
                3 : (Complex_type : Complex);
        END;

    Stack = RECORD
                Height : INTEGER;
                Stack_Member : ARRAY [1..MAX_HEIGHT] OF Stack_Rec;
            END;

PROCEDURE Push(VAR Stk : Stack;    { in/out }
               Element : Stack_Rec; { output }
               VAR OK : BOOLEAN    { output });
{ Procedure to push 'Element' in stack }
BEGIN
    WITH Stk DO BEGIN
        OK := FALSE;
        IF Height < MAX_HEIGHT
        THEN BEGIN
            OK := TRUE;
            Height := Height + 1;
            Stack_Member[Height] := Element
        END; { IF }
    END; { WITH }
END; { Push }


PROCEDURE Pop(VAR Stk : Stack;    { in/out }
              VAR Element : Stack_Rec; { output }
              VAR OK : BOOLEAN    { output });
{ Procedure to pop 'Element' in stack }
BEGIN
    WITH Stk DO BEGIN
        OK := FALSE;
        IF Height > 0
```

```
        THEN BEGIN
            OK := TRUE;
            Element := Stack_Member[Height];
            Height := Height - 1
        END; { IF }
    END; { WITH }
END; { Push }


PROCEDURE Selective_Pop(VAR Stk : Stack;   { in/out }
                        VAR Element : Stack_Rec; { in/out }
                        VAR OK : BOOLEAN   { output });
{ Procedure to search for first stack element that matches }
{ the Switch field in 'Element'.          }

VAR I, J : INTEGER;

BEGIN
    WITH Stk DO BEGIN
        OK := FALSE;
        I := Height;
        { Attempt to locate element of desired type }
        WHILE (I > 0) AND (NOT OK) DO
            IF Element.Switch = Stack_Member[I].Switch
            THEN OK := TRUE
            ELSE I := I - 1;

        IF OK THEN BEGIN { Found one! }
            Element := Stack_Member[I];
            { Rearrange stack }
            FOR J := I TO Height-1 DO
                Stack_Member[J] := Stack_Member[J+1];
            Height := Height - 1;
        END; { IF }
    END; { WITH }
END; { Selective_Pop }
```

End Listing Three

Listing Four A

```
DEFINITION MODULE HPStackMod;

EXPORT QUALIFIED
    HPStack, (* Opaque type *)
    Enter, Clst, Add, Sub, Mul, Div, RclLast, GetX; (* Procedures *)

TYPE HPStack;

PROCEDURE Enter(VAR Stack : HPStack; (* in/out *)
                X : REAL             (* input  *));
(* Procedure to enter a number in the stack *)

PROCEDURE Clst(VAR Stack : HPStack (* in/out *));
(* Procedure to clear stack and LASTX register *)

PROCEDURE Add(VAR Stack : HPStack (* in/out *));
(* Procedure to add Y and X registers *)

PROCEDURE Sub(VAR Stack : HPStack (* in/out *));
(* Procedure to subtract Y and X registers *)
```

End Listing Four A

Listing Four B

```
PROCEDURE Mul(VAR Stack : HPStack (* in/out *));
(* Procedure to multiply Y and X registers *)

PROCEDURE Div(VAR Stack : HPStack;  (* in/out *)
              VAR OK : BOOLEAN      (* output *));
(* Procedure to divide Y and X registers *)

PROCEDURE RclLast(VAR Stack : HPStack (* in/out *));
(* Procedure to recall LASTX register *)

PROCEDURE GetX(Stack : HPStack (* input *)) : REAL;
(* Function to get X register *)

END HPStackMod.


Listing Four B.
IMPLEMENTATION MODULE HPStackMod;
(* Module implementing scalar-based RPN stack calculator *)

TYPE HPStackRec = RECORD
                    XReg, YReg, ZReg, TReg, LASTX : REAL;
                  END;
    (* Exported opaque type *)
    HPStack = POINTER TO HPStackRec;

PROCEDURE StackDown;
(*------- Internal module usage ------*)
(* Procedure to roll down Y, Z and T registers *)
BEGIN
    YReg := ZReg;  (* Copy Z into Y *)
    ZReg := TReg   (* Copy T into Z *)
END StackDown;

PROCEDURE Enter(VAR Stack : HPStack; (* in/out *)
                X : REAL             (* input  *));
(* Procedure to enter a number in the stack and push it *)

BEGIN
    WITH Stack^ DO
        TReg := ZReg; ZReg := YReg;
        YReg := XReg; XReg:= X
    END;
END Enter;
```

(continued on next page)

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Listing Four B (Listing continued, text begins on page 116.)

```
PROCEDURE Clst(VAR Stack : HPStack (* in/out *));
(* Procedure to clear stack and LASTX register *)

BEGIN
    WITH Stack^ DO
        XReg := 0.0; YReg := 0.0; ZReg := 0.0;
        TReg := 0.0; LASTX := 0.0;
    END;
END Clst;

PROCEDURE Add(VAR Stack : HPStack (* in/out *));
(* Procedure to add Y and X registers *)

BEGIN
    WITH Stack^ DO
        LASTX := XReg; (* Save X reg. in LASTX *)
        XReg := YReg + XReg;
        StackDown
    END;
END Add;

PROCEDURE Sub(VAR Stack : HPStack (* in/out *));
(* Procedure to subtract Y and X registers *)

BEGIN
    WITH Stack^ DO
        LASTX := XReg; (* Save X reg. in LASTX *)
        XReg := YReg - XReg;
        StackDown
    END;
END Sub;

PROCEDURE Mul(VAR Stack : HPStack (* in/out *));
(* Procedure to multiply Y and X registers *)

BEGIN
    WITH Stack^ DO
        LASTX := XReg; (* Save X reg. in LASTX *)
        XReg := YReg * XReg;
        StackDown
    END;
END Mul;

PROCEDURE Div(VAR Stack : HPStack;  (* in/out *)
              VAR OK : BOOLEAN      (* output *));
(* Procedure to divide Y and X registers *)
```

End Listing Four B

Listing Four C

```
BEGIN
    OK := TRUE;
    WITH Stack^ DO
        IF StackReg[1] <> 0.0 (* Division by non-zero ? *)
        THEN
            LASTX := XReg; (* Save X reg. in LASTX *)
            XReg := YReg / XReg;
            StackDown
        ELSE (* Trouble *)
            OK := FALSE
        END;
    END;
END Div;

PROCEDURE RclLast(VAR Stack : HPStack (* in/out *));
(* Procedure to recall LASTX register *)

BEGIN
    WITH Stack^ DO
        TReg := ZReg; ZReg := YReg;
        YReg := XReg; XReg := LASTX
    END;
END RclLast;

PROCEDURE GetX(Stack : HPStack (* input *)) : REAL;
(* Function to get X register *)
BEGIN
    RETURN Stack^.XReg;
END GetX;

END HPStackMod.

Listing Four C.


IMPLEMENTATION MODULE HPStackMod;
(* Module implementing array-based RPN stack calculator *)


TYPE HPStackRec = RECORD
                    StackReg : ARRAY [0..4] OF REAL;
          (* StackReg[0] is LASTX, StackReg[1] is X Reg *)
          (* StackReg[2] is Y Reg, StackReg[3] is Z Reg *)
          (* StackReg[4] is T Reg *)
                  END;

    (* Exported opaque type *)
    HPStack = POINTER TO HPStackRec;

PROCEDURE StackDown;
(*------- Internal module usage -----*)
(* Procedure to roll down Y, Z and T registers *)
BEGIN
    StackReg[2] := StackReg[3];  (* Copy Z into Y *)
    StackReg[3] := StackReg[4] (* Copy T into Z *)
END StackDown;
```

```
PROCEDURE Enter(VAR Stack : HPStack; (* in/out *)
                X : REAL             (* input *));
(* Procedure to enter a number in the stack *)

VAR I : CARDINAL;

BEGIN
    WITH Stack^ DO
        FOR I := 3 TO 1 BY -1 DO
            StackReg[I+1] := StackReg[I]
        END;
        StackReg[1] := X
    END;
END Enter;

PROCEDURE Clst(VAR Stack : HPStack (* in/out *));
(* Procedure to clear stack and LASTX register *)
VAR I : CARDINAL;
BEGIN
   WITH Stack^ DO
       FOR I := 0 TO 4 DO
           StackReg[I] := 0.0
       END;
   END;
END Clst;

PROCEDURE Add(VAR Stack : HPStack (* in/out *));
(* Procedure to add Y and X registers *)

BEGIN
    WITH Stack^ DO
        StackReg[0] := StackReg[1]; (* Save X reg. in LASTX *)
        StackReg[1] := StackReg[2] + StackReg[1];
        StackDown

    END;
END Add;

PROCEDURE Sub(VAR Stack : HPStack  (* in/out *));
(* Procedure to subtract Y and X registers *)

BEGIN
    WITH Stack^ DO
        StackReg[0] := StackReg[1]; (* Save X reg. in LASTX *)
        StackReg[1] := StackReg[2] - StackReg[1];
        StackDown
    END;
END Sub;

PROCEDURE Mul(VAR Stack : HPStack  (* in/out *));
(* Procedure to multiply Y and X registers *)

BEGIN
    WITH Stack^ DO
        StackReg[0] := StackReg[1]; (* Save X reg. in LASTX *)
        StackReg[1] := StackReg[2] * StackReg[1];
        StackDown
    END;
END Mul;

PROCEDURE Div(VAR Stack : HPStack;  (* in/out *)
              VAR OK : BOOLEAN      (* output *));
(* Procedure to divide Y and X registers *)

BEGIN
    OK := TRUE;
    WITH Stack^ DO
        IF StackReg[1] <> 0.0 (* Division by non-zero ? *)
        THEN
            StackReg[0] := StackReg[1]; (* Save X reg. in LASTX *)
            StackReg[1] := StackReg[2] / StackReg[1];
            StackDown
        ELSE (* Trouble *)
            OK := FALSE
        END;
    END;
END Div;

PROCEDURE RclLast(VAR Stack : HPStack  (* in/out *));
(* Procedure to recall LASTX register *)
VAR I : CARDINAL;
BEGIN
    WITH Stack^ DO
        FOR I := 4 TO 1 BY -1 DO
            StackReg[I] := StackReg[I-1]
        END;
    END;
END RclLast;

PROCEDURE GetX(Stack : HPStack (* input *)) : REAL;
(* Function to get X register *)
BEGIN
    RETURN Stack^.StackReg[1];
END GetX;

END HPStackMod.
```

End Listings

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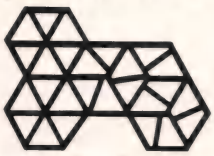

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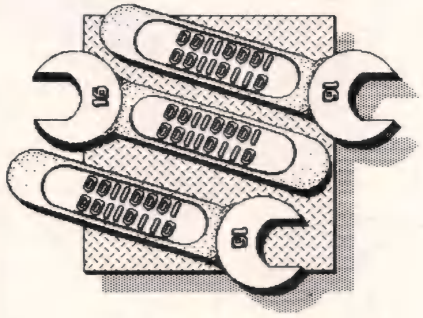

The DUP and FORCDUP Functions

MS-DOS functions *45H* (*DUP*) and *46H* (*FORCDUP*) have always been considered a little mysterious, except perhaps by those programmers who were nurtured under Unix. Both functions were added to MS-DOS in Version 2.0 at the same time as were the "extended file management" functions, and their documentation is a bit spare. The description in the *PC-DOS Technical Reference Manual* for function *45H* simply says that it "returns a new file handle that refers to the same file at the same position," and the explanation for function *46H* is that it "forces the handle in CX to refer to the same file at the same position as the handle in BX." In actuality, both of these functions are much more useful than the documentation suggests.

The *DUP* function (*45H*) is particularly convenient in applications that perform extensive file manipulation. Normally, the directory entry for a file is updated to reflect only the time and date last modified and the new length (if the file has been extended) when the file is closed. If your application extends a file and then crashes before closing the file, the new information at the end of the file is left floating in the form of lost clusters. Therefore, in programs that run for long periods, it would seem most wise to close and reopen a file whenever its length has been changed.

Unfortunately, the overhead of an open operation in MS-DOS is considerable, especially if the desired file is at the end of a fairly long path and is not in the current directory. You can avoid the open function altogether and still get your desired updating of the directory by *DUP*ing the handle for the open file and closing the duplicate. The close function turns out to be relatively fast in MS-DOS. See Listing One, page 106, for an example of this technique.

The *DUP*ed handle does subtract one from the maximum of 20 simultaneously active handles allowed for your process while it is open, but it doesn't count against the total number of open handles allowed for the system as a whole (the system total is set with the *files=* command in the config.sys file and defaults to eight).

The *FORCDUP* function (*46H*) can be used to redirect the input/output for any handle, previously opened to any logical device or file, to any other open device or file. The ramifications of this seem endless, but I suspect *FORCDUP*'s most common use is with the *EXEC* function to affect the behavior of the standard devices for child processes. Because the *open* handles of the parent program are inherited by the child, any desired redirection of the child's input or output can simply be put into effect at the parent's level before *EXEC* is called.

Jerry Jankura has been kind enough to donate a program that illustrates the use of *FORCDUP* to perform I/O redirection. It accompanies this month's column as Listing Two, page 106.

DOS Two-Point-What?

Last October, Microsoft released a revision of MS-DOS that hardly anyone has heard of—Version 2.25.

The main reason for MS-DOS 2.25's existence seems to be its enhanced character set support and interim character support, designed for the Far East OEMs that must support languages such as kanji and Korean. The *ASSIGN* and *LABEL* commands were added from MS-DOS, Version 3. In addition, MS-DOS 2's *DEBUG*, *SORT*, and *EDLIN* commands were replaced by MS-DOS 3.x's versions of the same. Many bugs reported in previous versions of MS-DOS (2.11 and earlier) were fixed.

Don't look for this version at your corner software store any time soon, though. Most U.S. OEMs appear to be ignoring it, even though it has less bugs, remains memory economical, and adds some of the desirable features of MS-DOS 3.x.

Windows Development Kit

Since its release late last year, Microsoft Windows has had surprisingly good market acceptance and in fact has been on the Softsel best-seller list for the last month as I write this. Although Windows is rather slow on the original 8088-based PC and is nearly unbearable without a hard disk, Windows on a PC/AT with an EGA is responsive and a pleasure to use. Prices for 80286-based PCs and fixed disks are decreasing rapidly, so it appears that if Windows was before its time hardwarewise, it was only just a little—though any significant penetration into the older PC user base will probably require the widespread availability of cheap turbo expansion boards and expanded memory boards.

Because of the dismal fates of ViSiOn and the PC version of GEM (seen any of those full-page color ads for GEM lately?), I was uncertain whether it was worth the time to pay any attention to Windows, how it works, and the machinations needed to write well-behaved Windows applications. The preliminary Windows development kit I received a year or so ago was intimidating to say the least, written as it was in the now-famous, infinitely self-referencing style of *Inside Macintosh*. To try and get some feeling for the future of

Windows, I attended Microsoft's Windows Developer Seminar in February in Seattle. I came away from this seminar with a changed outlook on Windows and what it portends for the future.

First, there is some confusion in the world of programmers about exactly what Windows is. Windows is not a desktop metaphor user interface like the one on the Mac. Icons are used in Windows only to symbolize tasks that are currently active in memory but do not have an open window or occasionally to select a resource (such as changing from one default disk drive to another). Icons are not used in Windows to represent and manipulate objects (files or programs) on a disk—you can't erase a file by dropping an icon in a wastebasket or copy a file by dragging an icon from one place to another, for example.

Windows is a multitasking executive, running on top of (and closely intertwined with) MS-DOS, that offers sophisticated memory management, dynamic loading and linking of code segments, intertask communication, a standardized virtual keyboard and pointing-device interface, and device-independent graphics services. Although Windows does have pull-down menus, tiled windows, scroll bars, and dialog boxes, these are in a way tangential to the intent and function of Windows. A pointing device can be used to advantage in Windows, but unlike the Mac, you can also get along quite nicely without one. The fact that well-behaved Windows applications will have a rather uniform user interface that dramatically shortens the learning curve for new users (as do Mac applications) can be viewed as just a nifty fringe benefit.

You are probably saying to yourself, "That all sounds great, but why should I as a programmer who uses MS-DOS worry about Windows now? Why not wait a year or two and see if Windows has any significant penetration of the user base I am concerned with and then decide whether to learn about its innards." You may be right. On the other hand, Microsoft made it clear at the seminar that much of the functionality of today's Windows (especially the multitasking and memory management) will be migrated downward into the MS-DOS kernel in future versions. In a sense, Windows can be thought of as a sneak preview of DOS 4 and 5 (in fact, the combination of MS-DOS 2 or 3 and Windows provides everything we were hoping for in the expected multitasking MS-DOS for the 8086/88-based PCs, and then some).

Windows apparently has even more significance for 80826-based PCs. Many of us have been a bit apprehensive about the upcoming Protected Mode versions of MS-DOS. Microsoft has been quite guarded on this topic until now, and the outlook has been further confused by leaks from IBM that it is developing its own Protected Mode operating system and by IBM's recent announcement that it is planning to use Digital Research's Concurrent DOS on a PC/AT-based point-of-sale product. At the seminar, Microsoft officials (including Steve Ballmer and Bill Gates) were suddenly surprisingly forthcoming with details about a Protected Mode MS-DOS. This may indicate that the major problems connected with this product have finally been solved.

During a panel discussion with members of the Windows development team and some outside Windows application developers, Gates asserted that the Protected Mode version of MS-DOS will be completely upward compatible with current MS-DOS versions and applications. Programs that are not well behaved (such as those that write directly to the video refresh buffer) will simply be executed in Real Mode and the fact that the operating system runs in Protected Mode will be invisible to them. In a way, this commitment to upward compatibility is somewhat unfortunate. Programs running in Real Mode, even under the control of a Protected Mode OS, can circumvent the 80286's mechanisms for protecting one task from another.

In other seminar sessions, guidelines were given for writing well-behaved programs under current versions of MS-DOS that will be able to run in Protected Mode on future versions and take full advantage of the 16-megabyte memory space. Ballmer, who has taken much of the flack for the many delays in Windows and was the author of the famous "before the snow falls" announcement, made a startling assertion. He said that well-behaved Windows applications created with the Windows development kit will run in Protected Mode on the upcoming PM version of MS-DOS without recompilation.

As for its own commitment to Windows, Microsoft laid it on the line in unmistakable terms. The company said that all future Microsoft applications (not languages) for the IBM PC that are not just evolutionary upgrades of existing packages will be Windows-dependent. Apparently, a port of Excel from the Mac to the PC is already underway for Windows. At first glance, such a policy seems a bit rash, but it may not be as risky as it sounds. The current Microsoft application packages for the PC (Word, Multiplan, and so forth) have been quite popular, and their quality is high; if future packages live up to the same standards, they may prove in themselves to be a potent driving force for Windows.

Those of us who attended the seminar each received a copy of the new retail release of the Windows Software Development Kit. This is a formidable package indeed, consisting of some 900 pages of typeset documentation in two volumes and a fistful of diskettes. The 12 floppies hold a special version of Windows with debugging support, Windows function libraries for C and Pascal, a library of macros for the folk determined to stick with assembler, an update to certain parts of the Microsoft C 3.0 compiler, a special linker, a modified SYMDEB that can be used with an external terminal or hooked to the PC's serial port, a dialog box editor, and so forth. A diskful of C source code for sample Windows applications is also included. Of course, in order to develop Windows programs, you must also buy the Microsoft C compiler, Pascal Compiler, or Macro Assembler separately.

The manuals for the development kit are nicely laid out and typeset but consist largely of reference material that is extremely dense. Only about a quarter of the material gives any guidance on the overall programming of a Windows application, and even in that section, it's rather difficult to see the forest for the trees. At the seminar, very helpful talks giving a more cosmic view were given by Microsoft programmers who have

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16-BIT

(continued from page 113)

been working within the Windows environment for two years or more and an additional volume of proceedings, programming guidelines, debugging examples, and sample source code was given to each attendee. Taken together, these remove much of the start-up fright factor from coding for Windows. If you are considering or embarking on a Windows-specific application, I'd highly recommend that you sign up for one of the scheduled developer's seminars—it will save you dollars and hours in the long run.

At this time, the ante for programmers who want to work with Windows is high. By the time you add up the cost of a PC/AT with 512K RAM, a hard disk and an EGA (the development configuration I would recommend), the Windows development kit, the Microsoft C compiler, and possibly a trip to Bellevue or Boston to attend the Microsoft Windows classes, you are talking about a lot of money. And if you aren't a C programmer, you're largely out of luck for the present. The Pascal and assembler support for Windows development seems rather half-hearted at best, and there are no bindings at all for FORTRAN, COBOL, or BASIC compilers.

If Microsoft is really committed to get Windows moving among software developers, I have a few suggestions for things it could do relatively quickly: release a Windows-specific version of BASIC similar to Mac BASIC; release a low-cost set of QuickBASIC bindings to Windows; release a lower cost, simplified Windows development kit for C programmers; and release a Turbo Pascal Windows toolkit. All these things should be priced around $100 to remove them from the "I wonder if I can talk my company into buying this" category and put them in the MasterCard/Visa, impulse-buy category. Of course, I am writing this in February, so when you read this in June, some lower-cost developer products may already be history.

The development kit can be ordered directly from the Microsoft Telemarketing Group [(800) 426-9400] and currently costs $500.

Building Overlays

Dr. Glenn Roberts of the Mitre Corp. responded to David Rabber's request for information on the overlay capability of the Microsoft linker (December 1985 column). He writes: "We obtained Version 3.01 of the Microsoft linker as part of the Microsoft C compiler package. This version of the linker supports overlays and the following information on it is condensed from the Microsoft documentation.

"You specify overlays in the list of modules that you submit to the linker by enclosing them in parentheses. Each parenthetical list represents one overlay. As an example, if the following were your response to the 'Object Modules' prompt:

Object Modules [.OBJ]:
a+(b+c)+(e+f)+g+(i)

then (*b*+*c*), (*e*+*f*), and *i* are overlays.

"Some pertinent notes:

- Overlays are loaded into the same region of memory, so only one can be resident at a time.
- Duplicate names in different overlays are not supported, so each module can occur only once in a program.
- The linker replaces calls from the root to an overlay and calls from an overlay to another overlay with a software interrupt, followed by the module identifier and offset. The default interrupt for calling this overlay manager is *03FH*.
- The names of the overlays are appended to the EXE file, and the name of this file is encoded into the program so that the overlay manager can access it. If the manager cannot find this file, it will prompt you for the file's name. After you've supplied the name, you can later swap disks in the associated drive. The overlay manager will detect this when it needs an overlay that is on a disk that has been removed and will prompt you to replace the disk and 'strike any key when ready.'
- The overlay manager is smart enough to search the current path for the EXE file.
- Control to overlay modules must be passed through far call/return sequences because the linker finds these and replaces them with the overlay interrupt. This rules out the use of indirect calls across overlays via pointers.
- You can change the default interrupt used to call the overlay manager using a switch on the linker:

/OVERLAYINTERRUPT:number

where *number* can be 0–0FFH.

"I should mention that I haven't experimented with the overlaying capabilities of this linker. I've merely stated, in condensed form, the information in the Microsoft documentation."

Another Resource for Programmers

The Programmer's Journal, edited by Robert Keller, is rapidly developing into a sort of modern-day equivalent of the original *Dr. Dobb's Journal of Computer Calisthenics and Orthodontia*. Casual and gossipy, yet stuffed with useful information, it definitely deserves a look. Contact the magazine at P.O. Box 30160, Eugene, OR 97403; (503) 484-2162.

DDJ on CompuServe

One of the Data Libraries (DL2) on the CompuServe DDJ Forum is devoted to the 16-Bit Software Toolbox, and most of the program listings published here in the last year or so are already available for downloading. If there are particular programs from farther back in the history of this column that you would like to see placed on the DL, please let me know. Also, I'd like to encourage everyone to use the DDJ Forum to send me comments, suggestions, criticisms, and programs. I guarantee quick response!

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(Listings begin on page 106.)

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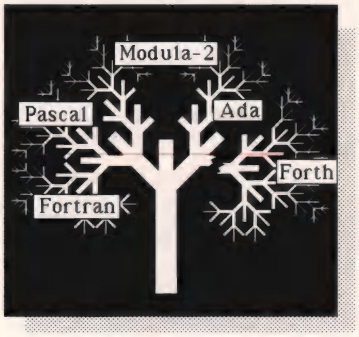

In this column dedicated to Pascal, Ada, and Modula-2—descendants of the ALGOL language—I will discuss language and implementation issues as well as applications written in them. The livelihood of any column draws from readers' interaction. *DDJ*'s CompuServe forum is an excellent place for fast feedback and dialogue; the U.S. mail is the slower alternative. You are invited to share your tips, tricks, and programming techniques.

In this issue I'll discuss two topics. The first part of the column deals with simulating overloaded procedures and functions in Pascal and Modula-2. The second part looks at exporting opaque types and data hiding in Modula-2.

Overloading Procedures

An overloaded procedure or function is one that exists simultaneously in several different versions within the same program. This allows you to use the same procedure call with several different kinds of arguments. An example of this is the Pascal intrinsic *Writeline( )*, which can take any number of arguments with many different data types. Unfortunately, Pascal and Modula-2 do not allow you to write overloaded routines explicitly because you're not allowed to create two functions or procedures with the same name in the same code body.

A Modula-2 program can import different libraries that may contain procedures with the same name. Thus you can import an entire library and use the overloaded procedure prefixed with the library name. Consider, for example, two library modules *RealInOut* and (a fictitious) *LongRealInOut* that take types *REAL* and *LONGREAL*, respectively, and both contain a procedure called *WriteReal( )*. To use the overloaded *WriteReal( )* procedure, you can call *RealInOut.WriteReal( )* or *LongRealInOut.WriteReal( )*. Because the two procedures called *WriteReal* are in different modules, the Modula-2 compiler is able to accept them.

Variant records provide a way to create "simulated" overloaded procedures. The simulation stems from the fact that there is really only one copy of the procedure. Admittedly, a bit more effort is required to make such procedures readable. The variant parts of a record enable the program to tackle different data items varying in basic type or number. I'll use three examples. The first overloads a routine that handles arrays of different basic data types. In this case, the macro structures are similar or identical but the micro structures are different. The second case deals with representing the same information with alternate notations. The third case shows a stack containing data structures of several types.

The first example (see Listing One, page 108) shows a Pascal procedure to perform a histogram count. In general, the input is an array of data items accompanied by an array of perfectly sorted histogram bin limits. Each bin limit gives the upper and lower bounds for the values to fall within one of the output slots of the histogram. This gives the flexibility that the histogram bin sizes need not be equal. Data values lying outside the histogram limits are ignored. The procedure *Count_Histogram* is capable of handling arrays of *REAL* as well as arrays of *STRING* data types. For the latter type, the variant records supply additional information. They include two integers that mark the first and last characters (within each string) of the substrings to be used for the bin comparison. Notice that the *Count* array is the only output in the variant record. Procedure *Count_Histogram* has its own local procedures to perform the frequency count for each different data type. You can easily add similar procedures to handle arrays of integers or characters.

Similar routines can be written to implement various searching and sorting techniques. In a future column I will discuss generic sorting. Generic routines provide a flexible solution to handle a wider variation in data types.

The second example, shown in Listing Two, page 108, looks at the situation in which information can be represented by alternate notations. You can represent a complex number (that is, a point on a two-dimensional graph) either by using rectangular coordinates (x and y) or by polar coordinates (modulus and angle). Thus you can have two sets of data each consisting of two *REAL* numbers. To process the information you must know what sort of coordinates are supplied. Listing Two shows a simple Pascal procedure to add two complex numbers. Each of the numbers can be supplied to the procedure as rectangular or polar coordinates, indicated by the *Is_Polar* field. Similarly the output can be obtained in either coordinate system. The example can be extended to systems of three or more dimensions.

The third example presents a stack that handles a variety of data types. Here, the differently typed items are more logically related. Compared with the histogram count example in which different data types are handled in parallel, this one handles them in series.

The fields of the variant portion contain the same number of identifi-

ers; only the types are different. Listing Three, page 108, shows three Pascal routines to push, pop, and selectively pop stack items. The nature of stack and queue manipulations permits them to accept multitype data in certain applications. Notice that the variant record contains user-defined record structures. You can add more variant fields without changing the code for the procedures. Unordered lists (single- and double-linked) can be constructed in a similar manner.

Exporting Opaque Types and Data Hiding

An opaque data type is one that includes no representation of the internal structure of the data. An example is the type *REAL*, the internal structure of which (the exponent and mantissa, along with their signs) is not available to the programmer. The Modula-2 feature of exporting opaque types and data hiding (sometimes referred to in Modula-2 books as data abstraction) has been with us all along, but originally it was a luxury only compiler writers enjoyed. It was impossible for us to use a data type exported from another module or library without explicitly stating its internal structure. Now this situation has changed with developments in software and hardware, and Modula-2 offers similar privileges to library module developers. This is done by having the definition module state the exported data type name only, with no structure definition. Hence, the opaque type is born. The implementation module has the complete type definition along with all the routines to manipulate it. Modula-2 requires that opaque types be defined as pointers to other data types. The client programs importing the opaque types do not have access to their internal structure, and thus they cannot have their own procedures to manipulate the opaque types. The library developer is responsible for providing every routine needed!

By hiding the internal structure of an opaque type, library authors can modify it, and the procedure bodies, without affecting client programs. They may want to do this for a variety of reasons, such as prototyping or discovering a superior or more convenient alternate structure.

Applications for exporting opaque types are numerous. The simplest example is string libraries. Table 1, below, shows four alternative definitions for an opaque string type. The first three string types use a finite array to store characters. The fourth type uses true dynamic dimensioning by employing the imported type *ADDRESS*.

The type *string1* is straightforward. The implementation procedures must rely on ASCII zero code as the string terminator for partially filled strings. The type *string2* incorporates a string length counter. Using it along with the predefined *HIGH( )* function, which returns the upper bound of the character array, the appropriate string lengths are managed. Exporting this type as transparent may cause problems with user-written procedures that corrupt the length counter, and thus the use of an opaque type in this situation is more attractive and justifiable. The third type is a slight modification of *string2*, adding a total string counter. Ford and Wiener[1] discuss this string type and point out that the structure uses the total length field dynamical-

```
CONST MaxLength = 255; (* or any other length, up to 65535 *)
(* Alternative # 1 *)
TYPE string1 = POINTER TO RECORD
                    strch : ARRAY [0..MaxLength] OF CHAR
               END;
(* Alternative # 2 *)
TYPE string2 = POINTER TO RECORD
                    long : CARDINAL;
                    strch : ARRAY [0..MaxLength] OF CHAR
               END;
(* Alternative # 3 *)
TYPE string3 = POINTER TO RECORD
                    long,
                    TotalLength : CARDINAL;
                    strch : ARRAY [0..MaxLength] OF CHAR
               END;
(* Alternative # 4 *)
(* Note: ADDRESS type is imported from module SYSTEM *)
TYPE string4 = POINTER TO RECORD
                    long,
                    TotalLength : CARDINAL;
                    strch : ADDRESS
               END;
```

Table 1: *Alternative Modula-2 opaque string structures*

```
(* Matrix may have negative indices *)
TYPE Matrix1 = POINTER TO RECORD
                    FirstRowIndex,
                    LastRowIndex,
                    FirstColumIndex
                    LastColumIndex : INTEGER;
                    (* ADDRESS is Imported from SYSTEM *)
                    MatrixMember : ADDRESS
               END;
(* Matrix with zero or positive indices *)
TYPE Matrix2 = POINTER TO RECORD
                    LastRowIndex ,
                    LastColumIndex : CARDINAL;
                    (* ADDRESS is Imported from SYSTEM *)
                    MatrixMember : ADDRESS
               END;
```

Table 2: *Dynamic opaque matrix structure*

(continued from page 117)

ly. The *ALLOCATE( )* procedure is used instead of *NEW( )* to accomplish the above task. Employing *ALLOCATE* forces the run-time system to create a dynamic structure according to the actual record size, which may be smaller than the maximum allowable size. The fourth string type differs from the others in that none of its fields is an array of characters. Like *string3* it contains fields to keep track of the current string length and the total size is dynamically allocated. The field of type *ADDRESS* is the pointer that locates the actual character string. The advantage of type *string4* is the creation of strings with tailored sizes.

Another example of alternative representation is complex numbers, discussed earlier. It is possible to have two library implementation modules: one for rectangular coordinates, the other for polar coordinates (see Ford and Weiner: 177). Because opaque types are involved, procedures to create and return the real and imaginary parts of a complex number must be supplied to client programs.

Modula-2 supports only one-dimensional open arrays in procedure arguments. Ford and Wiener present a dynamic matrix library exported as an opaque data type. The matrix is defined as a pointer to a record that contains the upper and lower dimension limits and an identifier of type *ADDRESS*, as shown in Table 2, page 117. This structure allows you to create matrices tailored to size, although speed is on the slow side.

Other popular data structures such as binary and B-trees can also be exported as opaque types. Multiway trees such as the B-tree, B+ Tree, B* Tree,[2] and B++ Tree[3] examples of complex data structures. Library database developers may start by exporting a B-tree structure as an opaque type. Hiding the exact structure gives them the ability to select one of the above structures or implement their own refinements, which may involve adding more pointers or resizing the B-tree page. One problem generally encountered with such data types occurs when you perform I/O with files. As the data structure changes, the new library version must be able to identify and read previous structures saved in files.

The simple example presented in Listing Four, page 109, deals with a module exporting procedures to simulate a basic RPN calculator with four stack registers (*X*, *Y*, *Z*, and *T*) and a *LASTX* register, similar to a Hewlett-Packard calculator. Parts A, B, and C of the listing show the definition module and the two implementation modules, respectively. In part B the stack is formed by five scalar identifiers, whereas part C shows an array representation. The zeroth member corresponds to the *LASTX* register, the first to the *X* register, and so on. It is interesting to note that, while using the array representation, a *FOR* loop can be used to push and pop the stack. The scalar representation is more readable, however. The *HPStackMod* module exports four basic operations—number entry, stack clearing, recalling *LASTX* into the *X* register, and a function to return the *X* register. The latter function, which may seem extremely trivial, is nevertheless essential because of the use of an opaque type to represent the stack.

An Invitation

I encourage you to send me short utility routines or programs that perform useful tasks—for example, tapping into hardware and operating systems. I'm also looking forward to the validation of the IBM PC/AT Ada compiler by Alsys Inc. Obtaining a copy of this will help my discussions about the language.

Notes

1. G. Ford and R. Wiener, *Modula-2: A Software Development Approach* (New York: John Wiley & Sons, 1985).
2. M. Loomis, *Data Management and File Processing* (Englewood Cliffs, N.J.: Prentice-Hall, 1983).
3. N. Shammas, "B+ trees, B++ trees, and statistics in AI," *Computer Language*, 2 (6) (1985): 13–18. **DDJ**

(Listings begin on page 108.)

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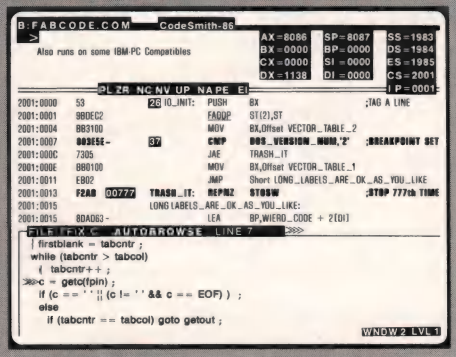

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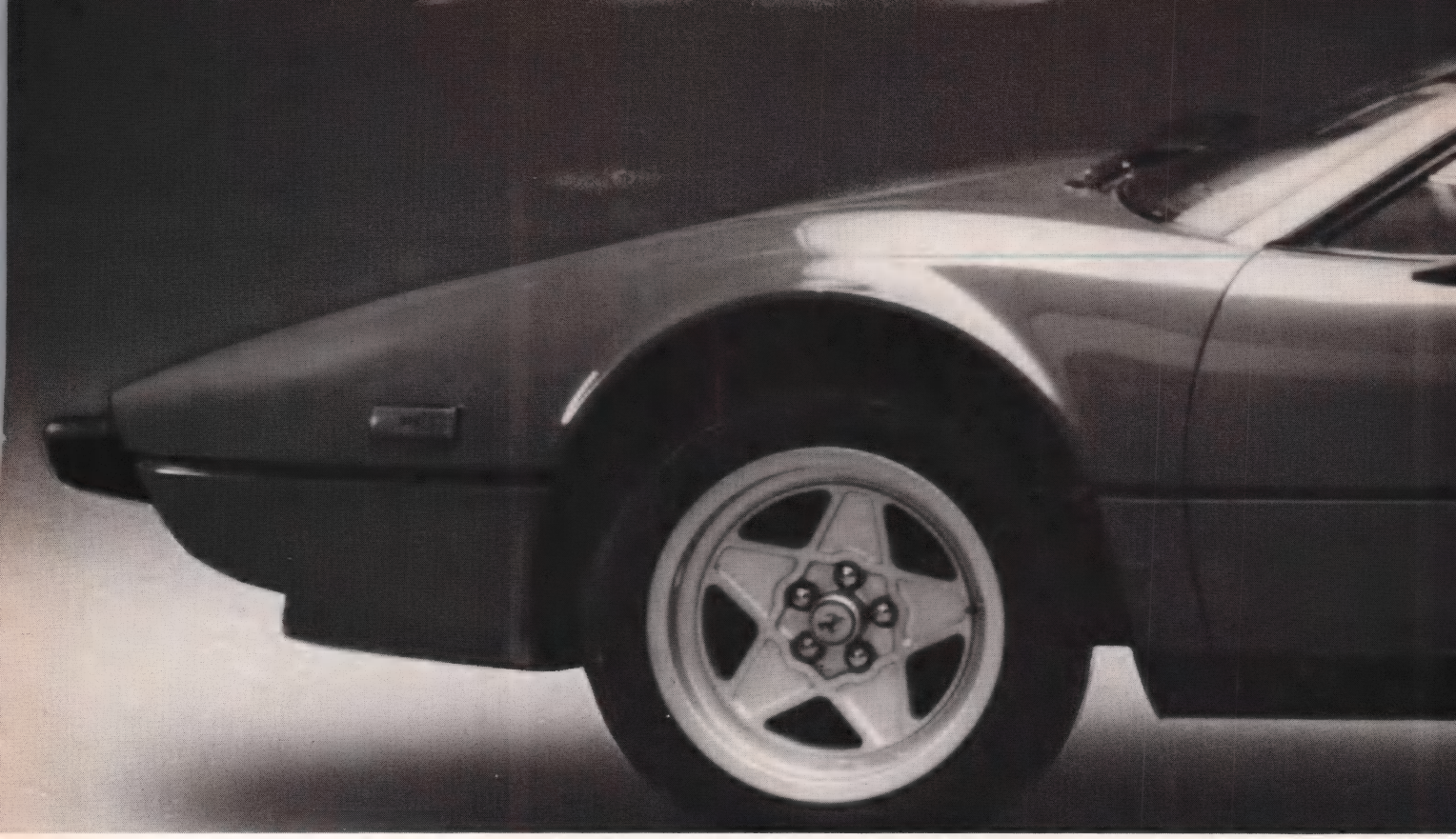

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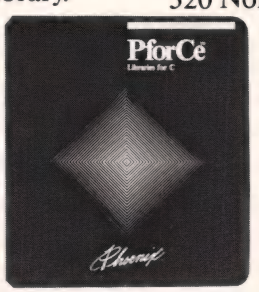

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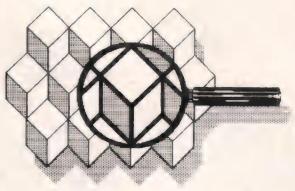

Corporations today face the same problems that motivated the Department of Defense (DOD) to create a standard programming language and eliminate the proliferation of languages and dialects that contribute to astronomical software upkeep costs, estimated at 80 percent of total systems maintenance. Mandated for all DOD mission-critical applications, the Ada programming language is expected to have increasing importance for all commercial applications. Historically, the lack of compilers has inhibited the widespread use of Ada.

An Ada compiler for the IBM PC/AT from **Alsys** enables full-scale Ada application programs to be written for the PC. Through the use of protected (virtual) mode, the compiler permits an application program to overcome the 640K limitation imposed by the DOS operating system and to access extended memory (up to 16 megabytes on the PC/AT). The compiler is packaged with a 4-megabyte memory board. It also features 8086 or 80286 instruction, an online help facility, and error checking. The compiler for the IBM PC/AT is priced at $3,000.

Tartan Laboratories has developed a C programming language compiler for the IBM PC/RT. Both an Ada and a Modula-2 compiler for the IBM PC/RT are currently under development.

An Ada compiler system for the IBM PC, PC/XT, PC/AT, and compatibles is available for $895 from **Artek Corp.** The compiler system meets virtually all the latest DOD specifications except "tasking" and runs under the MS-DOS or PC-DOS operating system on PC-compatible computers having at least 384K of memory. Hard-disk mass storage is recommended for the development of large applications. Demonstration disks are offered for $29.95. The full system is available to buyers of the demonstration disk for $29.95 less than the regular price.

Artificial Intelligence

Microsoft's LISP 5.1 offers more primitives, greater capacity, expanded arithmetic, improved debugging, and faster list sorting than do earlier versions. It also features common LISP support and split-screen capabilities. Minimum system requirements for Version 5.1 are a PC running MS-DOS or PC-DOS 2.0 or later, 128K of memory (although Microsoft recommends at least 256K), and one disk drive (two are recommended). It has a suggested retail price of $250.

OPS83, the high-performance expert systems programming language from **Production Systems Technologies**, is available for use on the IBM PC and compatibles. This version of OPS83 is identical to the original version introduced in 1984 for use under VMS and Unix on the VAX series machines and Apollo Domain. Recently, it has been made available for use on the MicroVAX, Sun Workstation, and AT&T's 3B series. It retails for $1,950.

An integrated systems development environment for planning, analyzing, designing, and constructing computer-based information systems is available from **KnowledgeWare.** Called the Information Engineering Workbench, this software family uses expert system and computer-aided design and programming techniques to automate information engineering. The new family includes an integrated set of diagramming tools for several common diagram types, including entity, decomposition, data-flow, and action diagrams.

C Language

Raima Corp. has announced Version 2.1 of db_Vista, its database management system for software development in the C programming language. It is designed for use with MS-DOS or Unix-like operating systems. The new version features improved B-tree key field handling; a key-file rebuild utililty; a database consistency check utility; a data-field alignment check utililty; and file-transfer utilities for dBASE, R:base, and ASCII files. The db_Vista multiuser version costs $990 with source and $495 without source. The single-user version is available for $495 with source and $195 without.

High C, a C cross compiler implemented for VAX/VMS running on the Intel 8086/88/186/188/286 family of microprocessors, is available from **Microtec Research.** High C features support for ROMable code for embedded applications, nested functions complete with up-level references, nested functions passable as parameters, a full set of memory models, three integer ranges, and three IEEE real precisions. The product also contains many compiler controls and options, including one for strict ANSI standard checking. The complete High C software package costs $7,000 and operates on DEC VAX under VMS.

Computer Innovations has released a free booklet on its Optimizing C86 C compiler. The features of the C86 discussed include language conformance, Unix compatibility, and source-level debugging support. The booklet also features a complete listing of run-time options and functions.

Fast Programming from **Subject, Wills & Co.** is a C generator tool for business-application developers. The product includes a B+ tree index facility, a field-independent record management system, a complete set of run-time utilities, a library of C routines, and several C program generators. Fast Programming sells for $995 for a site license. It is available for PC-DOS and Xenix on the IBM PC/AT and Unix V on the AT&T 3B2/3B5 computer line.

Version 2.0 of Bastoc from **JMI Software Consultants** translates BASIC programs into C. Bastoc analyzes the use of numeric variables to determine which floating-point variables can be replaced by integer variables. Additional optimizations include eliminating unreachable code; converting BASIC assignment statements, where possible, into simpler increment or decrement operations available in C; and evaluating string expressions at compile

time. The product includes a BASIC compiler program. Binary versions are available for the IBM PC and compatible systems using MS-DOS, the AT&T 3B2 (Unix V), the AT&T Unix PC/3B1 (Unix V), the Radio Shack Model 16 (Xenix), Sperry 5000 (Unix V), and several additional Unix and Unix-like systems. The price for single-user systems is $495.

Application Development

Version 6 of **Netron's** computer-automated programming development software for the Wang VS includes a feature that allows automatic control of in-house screen design standards for file-maintenance programs. The new version also adds background processing from user-defined function keys and supports use of qualified data names. The program includes a built-in standard ANSI 74 COBOL and is suitable for running production systems of any size and complexity.

The **Oasys** 68020 Toolkit features a complete line of compilers (C, Pascal, FORTRAN-77), assemblers (including linker, loader and librarian), debuggers, simulators, profilers, real-time OS, and down-line load utilities. Support for the 68881 floating-point processor is also provided. The Toolkit is available for DEC VAX (VMS, Ultrix, Unix), DEC MicroVAX (VMS, Ultrix), Sun, Apollo, Pyramid, PCs, and other 68000 and 32000 systems running Unix. A typical configuration of a C compiler, assembler, linker, and librarian starts at $3,200 in single quantities.

Release 5.0 of **STSC's** APL*Plus PC System adds speed to the development process with its APL language notation. The run-time version is an adaptation of the APL*Plus PC system specially modified to run a single application. This modified interpreter enables developers to include enough of the APL*Plus system to run their applications but not enough to allow end-users to write or modify their own APL programs. The run-time system is licensed on a royalty or per-copy basis.

Release One, Version 3.06, of Q'Nial from **Nial Systems** is a high-level interactive interpreter that handles symbolic and numeric computation with equal facility. It is used primarily in logic programming and other artificial intelligence applications. A Q'Nial license costs $300 for PC/XT/AT versions. The entire package, including media and shipping, costs $375. Educational licenses are half-price. A site license for educational institutions costs $500.

For the IBM PC

DSD86 from **Soft Advances** is a full-screen symbolic debugging program for IBM PC-compatible computers running PC-DOS or MS-DOS. DSD86 offers a built-in windowing system for a user-controlled screen layout with six different display types, including instructions, registers, stack, memory, and source. The keyboard interface can be customized, permitting arbitrary command lines to be bound to any Ctrl, Alt, or function key. A recursive

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(continued from page 121)

macro facility allows consistent extensions to the set of 45 commands provided by DSD86. The list price is $69.95.

Programmers for the IBM System/38 computer can write and edit RPGIII source code on an IBM-compatible personal computer using the Baby/38 Source Entry Utility (SEU), a software package from **California Software Products.** Baby/38 SEU emulates the System/38 source entry utility to provide full-screen editing without the expense of System/38 hardware. Moving editing functions off-line to a PC frees the System/38 for other tasks and permits programming to continue even if the system is down. Baby/38 SEU requires an IBM or fully compatible PC with a minimum of 384K memory, DOS 2.0 or later, parallel printer port, and dual-floppy or floppy- and hard-disk drives.

Applied Data Research has released Version 2.0 of ADR/PC Datacom, a PC-based query and report writing facility. PC Datacom supports the exchange of data between an IBM PC and a mainframe as well as other PC functions. The new version features PC-based query creation and host data download and upload, a full-function report writer, data export and import for the exchange of data between PC spreadsheets and other application software, and a procedure facility for unattended and repetitive tasks. The product operates on any standard IBM PC, PC/XT, or PC/AT computer using PC-DOS 2.0 or later. It requires a minimum of 512K memory and two dual-sided, floppy-disk drives or a hard-disk drive. The IBM 3270 PC is also supported and requires 640K of memory.

Flagstaff Engineering has announced three products—File Connection, Word Connection, and Tape Connection—for data/text transfer to and from the IBM PC or compatibles. File Connection is a 3½-, 5¼-, and 8-inch disk subsystem that interfaces to a PC and allows users to transfer files from many different systems. Word Connection allows transfers between different word-processing systems, such as Displaywriter, Lanier, OS/6, NBI, Wang, Xerox 860, CPT, Microsoft Word, Multimate, and WordStar. The Tape Connection is a half-inch magnetic tape drive interface that allows transfer of files from a PC to tape and back.

Maxit, a memory card with software that expands available memory on an IBM PC, PC/XT, PC/AT, or compatible computer, is available from **McGraw-Hill Software.** Maxit requires DOS 2.0 or later and can fill out the memory of the IBM PC/AT, taking it from 512K to 640K and beyond. Maxit is priced at $195.

Hallock Systems has announced three enhancements to its Pro68 product line. DOS68 is a PC-DOS-compatible operating system designed for use on the Pro68 or Pro68/10 coprocessor cards. It is available for use with C, Pascal, Forth, BASIC, and FORTRAN. The system sells for $150. Pro68/10 is a single printed-circuit card that can be installed in any full-size PC, PC/XT, or PC/AT bus slot. The card includes a 68010 microprocessor running at 12 MHz, up to 1,024K of on-board 16-bit parity-checked memory, provisions for a 6-MHz math processor, two serial I/O channels, a 16-bit 680x0 expansion bus, and a proprietary dual-ported PC bus interface. Pro68/10 is available in two configurations, costing from $1,995 for the 512K version and from $2,195 for the 1,024K version. RTX68 is a time-sliced multitasking executive that supports up to 256 concurrent tasks. Each task is assigned one of 256 possible priority levels that can be changed during run time on a dynamic basis. RTX68 is designed to run concurrently with the host system PC-DOS. It is available for $150.

The IBM PC-compatible RS-232 5¼-inch Floppy Data Storage and Transfer System is available from **Analog & Digital Peripherals.** It features host and/or manual controls, ASCII or full binary operation, baud rates switch selectable from 110 baud to 19.2K baud, and automatic data verification. It is available in 110 VAC stand-alone or OEM configurations. The stand-alone system is priced at $1,095.

Communications

Quadram has launched its MainLink line of micro-to-mainframe communications solutions with four 3278/79 emulation products. Two of the products, the MainLink Standard coaxial connection and the MainLink Plus coaxial connection, link directly to an IBM 3274 or 3276 cluster controller for local or remote processing. Both are Irma compatible. They are also equipped with soft-loaded microcode, permitting upgrades to be made with a floppy disk. The MainLink Standard remote and MainLink Plus remote attach via synchronous modem to an IBM 3705, 3725, or equivalent communications controller in SNA/SDLC mode. Both permit emulation of an IBM 3274 cluster controller and 3287 host-addressable printer. The four products retail as follows: MainLink Standard coaxial, $895; MainLink Plus coaxial, $1,145; MainLink Standard remote, $545; MainLink Plus remote, $985.

SoftCraft has a new release of its Btrieve file management software for the IBM PC/AT and compatibles. Btrieve 4.0 and Btrieve/N 4.0 (for multiuser and LAN systems) feature variable-length records, data encryption, password protection, and a file-level verify option. Both are for software development in BASIC, Pascal, COBOL, C, FORTRAN, Modula-2, and APL. They cost $245 and $595, respectively.

Network-OS 6.0, a Netbios-compatible, network operating system, supports DOS 3.1, all major network topologies, and Novell file and record locking. Available from **CBIS**, Network-OS is menu-driven, and commands are presented on hierarchical, pull-down screens. LAN resources are addressed by user-defined object names and mapped by mouse or keyboard. The retail list price of Network-OS is $995. Interface boards cost $295.

Lamar Micro has developed a 65C02 cross assembler program for the Atari 520 ST on Atari format disk. This program, called C02 Cross Assembler, allows the Atari to act as a software development system for Apple, Atari, and Commodore computers that use the 6502 or 65C02 microprocessor. The price of the program is $89.95.

TDI Software has released a Modula-2 for the Commodore Amiga. The software features full in-

terface to ROM Kernal, Intuition and AmigaDOS, 32-bit native code implementation, support for transcendental functions and real numbers, separate compilation of modules with version control, Code statement for inline assembly code, and the ability to locate and identify errors in source code. The Modula-2 comes in regular and developer's versions. The developer's version has an extra disk containing all the definition module sources, a symbol file decoder, link and load file disassemblers, a source file cross-referencer, the kermit file-transfer utility, and the source code for several of the Amiga modules. The retail price of the regular version is $89.95; the developer's version is $149.95.

Peachtree Technology has introduced the T-33e Back-Up Subsystem. The T-33e utilizes the existing external floppy port on any IBM PC, PC/XT, PC/AT, or compatible. It is MS-DOS-compatible and can back up 30 megabytes. An LED readout provides users with tracking, power, and drive information and offers self-diagnostic capabilities, including an on-board error-detection device. The T-33e retails for $795 and comes with two 10-megabyte reels. It also comes in an internal half-height configuration that retails for $695.

Mastercom-Telecommunications Utility is a smart-terminal and file-transfer utility available for the IBM PCjr and most IBM PC-DOS- and CP/M-80-compatible computers. Mastercom, available from **The Software Store**, is designed to capture data onto a disk and/or printer, send files, and transfer files using the Christensen XMODEM error-correcting protocol. It includes auto-dial, auto-answer, host-mode unattended operation, batch-file transfer, directory display, file erase, file rename, disk-drive logging, stored responses, and more.

Samsung Semiconductor has introduced two families of high-performance CMOS logic products: the 54/74 Advanced High-Speed CMOS and the 54/74 High-Speed CMOS. The two product families contain 63 devices, including octal buffers, octal transceivers, octal latches, and inverters. They also feature low power dissipation, high levels of noise immunity, low input currents, wide operating voltage supply and temperature ranges, 4,000V ESD protection, and the ability to handle latchup trigger currents above 200 ma.

The Epsilon Extension Language from **Lugaru Software** is an interpreted, dynamically linked extension language that resembles C, augmented with functions and variables to facilitate writing editor extensions. It features source code for all commands, unlimited file size, an on-line tutorial, an EMACS-style command set, language support, command-name and file-name completion, and full DOS path support. Epsilon's price is $195.

Watcom Products has released Maple, an interactive system for algebraic computation. Maple provides diagnostic and debugging facilities and supports two output formats: two-dimensional, multiline format and one-dimensional, line-printing mode. It is available for IBM VM/SP CMS, Digital VAX/VMS, and Unix (4.2BSD) for a yearly license fee of $1,400 for commercial users.

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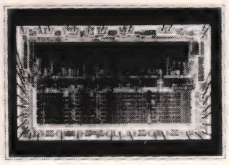

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OF INTEREST
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White Sciences' Icon Builder software allows the generation of graphics images that can be printed, overlayed on a digitizing tablet surface, and used to augment the limited keyboard space in the construction of icon-oriented user interfaces to application programs. Icon Builder is composed of four software modules: a graphics program, a template editor, a template install program, and an overlay print program. It retails for $79.95.

BMC Software's Data Packer II is a second-generation IMS utility that provides multiple database compression options. Data Packer II reduces DASD space requirements, often by more than 75 percent, thereby reducing the many direct costs affected by DASD needs and high transaction levels. The product is available at $25,000 for a perpetual lease on the first CPU.

RM/COBOL from **Ryan-McFarland Corp.** is a GSA-certified implementation of the ANSI X3.23 74 COBOL standard. It is available under an OEM's custom operating system or under standard systems. RM/COBOL features an indexed file-access method, record- and file-level locking, full arithmetic capability, and interactive screen-handling capabilities.

XTree, Version 2.0, from **Executive Systems** is designed to simplify file and directory handling by providing single keystroke commands to access, delete, rename, view, move, list, or show files within any directory on a floppy and hard disk. Version 2.0 requires an IBM PC or PC/AT with 19K of memory and MS-DOS 2.0 or PC-DOS. The program retails for $49.95.

The Sibec-II, a single-board microcontroller, is available from **Binary Technology.** Sibec-II features the 8052-AH CPU with full floating-point BASIC. The auto baud rate RS-232 connector allows users to connect a terminal and begin programming. The unit is available for $295.

Reference Map

Alsys Inc., 1432 Main St., Waltham, MA 02154; (617) 890-0030. Reader Service Number 16.

Analog & Digital Peripherals Inc., 815 Diana Dr., Troy, OH 45373; (513) 339-2241. Reader Service Number 17.

Applied Data Research LInc., Rte. 206 and Orchard Rd., CN-8, Princeton, NJ L08540-9936; (201) 874-9000. Reader Service Number 18.

Artek Corp., 101 Seaview Dr., Secaucus, NJ 07094; (201) 867-2900. Reader Service Number 19.

Binary Technology Inc., Main St., P.O. Box 67, Meriden, NH 03770; (603) 469-3232. Reader Service Number 20.

BMC Software, P.O. Box 2002, Sugar Land, TX 77478; (713) 240-8800. Reader Service Number 21.

California Software Products Inc., 525 N. Cabrillo Park Dr., Santa Ana, CA 92701; (714) 973-0440. Reader Service Number 22.

CBIS Inc., 2323 Cheshire LBridge Rd., Atlanta, GA L30324; (404) 634-3079. Reader Service Number 23.

Computer Innovations Inc., 980 Shrewsbury Ave., Tinton Falls, NJ 07724; (201) 542-5920. Reader Service Number 24.

Executive Systems Inc., 15300 Ventura Blvd., Ste. 305, Sherman Oaks, CA 91403; (800) 634-5545, in CA (800) 551-5353. Reader Service Number 25.

Flagstaff Engineering, 1120 Kaibab Ln., Flagstaff, AZ 86001; (602) 779-3341. Reader Service Number 26.

Hallock Systems Co. Inc., 267 N. Main St., Herkimer, NY 13350; (315) 866-7125. Reader Service Number 27.

JMI Software Consultants Inc., 904 Sheble Ln., P.O. Box 481, Spring House, PA 19477; (215) 628-0846. Reader Service Number 28.

KnowledgeWare Inc., 2006 Hogvack, Ann Arbor, MI L48105; (313) 971-5363. Reader Service Number 29.

Lamar Micro, 2107 Artesia Blvd., Redondo Beach, CA 90278; (213) 374-1673. Reader Service Number 30.

Lugaru Software Ltd., 5740 Darlington Rd., Pittsburgh, PA 15217; (412) 421-5911. L Reader Service Number 31.

McGraw-Hill Software, Ste. 1350, 8111 LBJ Fwy., Dallas, TX 75251; (214) 437-7422. L Reader Service Number 32.

Microsoft Corp., 16011 N.E. 36th Wy., P.O. Box 97017, Redmond, WA 98073-9717; (206) 882-8080. Reader Service Number 33.

Microtec Research, 3930 LFreedom Cir., Ste. 101, Santa Clara, CA 95054; (800) 551-5554; in CA (408) 733-2919. Reader Service Number 34.

Netron Inc., 99 St. Regis LCrescent North, Downsview, Ont., Canada M3J 1Y9; (416) 636-8333. Reader Service Number 35.

Nial Systems Ltd., P.O. Box 280, Alexandria Bay, NY 13607-0280; (800) 267-0660. Reader Service Number 36.

Oasys, 60 Aberdeen Ave., Cambridge, MA 02138; (617) 491-4180. Reader Service Number 37.

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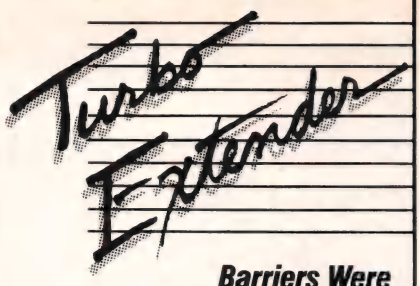

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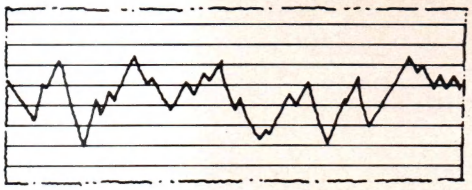

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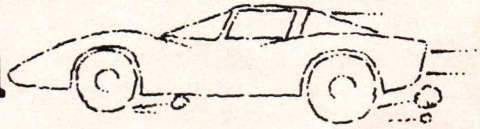

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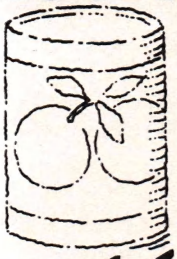

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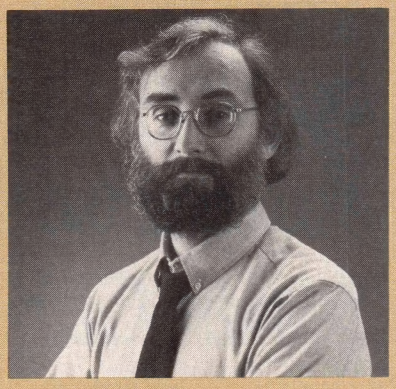

Exactly two years ago we published a review of Borland's Turbo Pascal; within the next two months we expect to review Turbo Prolog, assuming we get the product in time (the editor's perennial lament). When I finish this column I intend to drive to Scotts Valley and request a copy in person. That sometimes works.

Column? you ask, flipping through back issues, asking your fickle memory what was on this page before. Certainly not this column with a goofy photo of the editor-in-chief posed like Peter Norton. What are they doing to *DDJ* now?

Glad you asked. This is indeed a new column, written by me, Mike Swaine, editor-in-chief, a column born of the need to have new editor Nick Turner and me flame in parallel (he gets the editorial page) and of the desire to put an opinion column on the last page like many other magazines do.

Oh, fine. Now *DDJ* will start sounding like *InfoWorld*. Ersatz Dvorak, right? Well, no; I hope this will be a *DDJ*-type back-page column, dealing with *DDJ*-type issues from a *DDJ*-type perspective. If the styles of other columnists influence this column, they will be the the columnists who influenced me in my formative years.

I read and enjoyed John Campbell's convention-challenging editorials in *Analog Science Fiction* magazine even after I grew up and learned that they were sophomoric and slightly cracked. I was permanently warped by Martin Gardner's rich, witty, and diligently researched Mathematical Games column in *Scientific American*, and I imitated it in a puzzle column of my own on the back page of *InfoWorld* for a year or so. More recently, I liked Hal Hardenbergh's quirky column-that-ate-the-newsletter in *DTACK Grounded*, but I don't have room here to imitate Hal.

What will this column cover? The usual stuff: significant new software products, books, trends, phenomena. I admire Jon Bentley's Programming Pearls in *Communications of the ACM*, which have been collected into a book also titled *Programming Pearls* (Reading, Mass.: Addison-Wesley, 1986). Bentley has staked out as his domain insight and creativity in programming. Fertile ground, which he tills like a native. I think his is the best new computer book of 1986.

A good column should stimulate its readers to think, not try to think for them. I don't, for example, know the significance of Microsoft's decision not to support .COM files in future versions of DOS (beyond the fact that it's a repudiation of DOS's illegitimate descent from CP/M), but I suspect there may be ramifications that Microsoft hasn't considered.

A good column asks questions, but not just the most obvious ones. Will Borland sell hundreds of thousands of copies of Turbo Prolog? Maybe, but what would it signify if it did? Oddly, despite the fact that Pascal and PROLOG are from different planets, the experience of Turbo Pascal could provide an idea of how Turbo Prolog will be received—breathless reviews in the computer press, reckless spending by under-informed computer owners, confusion over the significance of the PROLOG language, mistaking a good user interface for product depth. Turbo Prolog could be absurdly successful for reasons no less absurd. And yet, the effect on professional software development could turn out to be negligible.

Finally, I hope to tell about the work of an enterprising software developer with a genuinely new idea each month. Take my cousin Corbett, who, having lost his shirt in the software look-alike market when his line of software (called Look and Feel Ware and marketed under the Kalvin Klone label) ran up against some stiff competition, hit upon one of those ideas that leave you speechless with awe.

Corbett's latest line of products is called Tomorrow's Software. Tomorrow's Software does nothing except display so-far-unused icons, shapes, and colors on the screen. Corbett's visionary idea is to stake out new visual metaphors in order to collect royalties from people who will later learn what to do with them. The hall-closet metaphor. The hero-sandwich metaphor. The sheep-entrails metaphor. I think he's onto something. Just yesterday he called to tell me that he'd found a color that had never been put to functional use on the computer screen, and he was applying for a patent on its use. The big question is whether he can sue Steven Spielberg over his use of the color purple.

Yeah, but what's this Borland business? you ask, ignoring the last two paragraphs. If Turbo Prolog may have only negligible significance for software developers, why review it in a software developer's magazine? Well, what I really suspect is that Borland is onto something. I think it's just possible that Turbo Prolog will be significant in the history of software, but it will be so only if Borland is successful in getting it quickly into college classrooms and only if the product is good.

So if you'll excuse me, I'm off to Scotts Valley.

Late news dept.: Dvorak makes **bold** move to *PC Magazine*.

Michael Swaine

Michael Swaine
editor-in-chief

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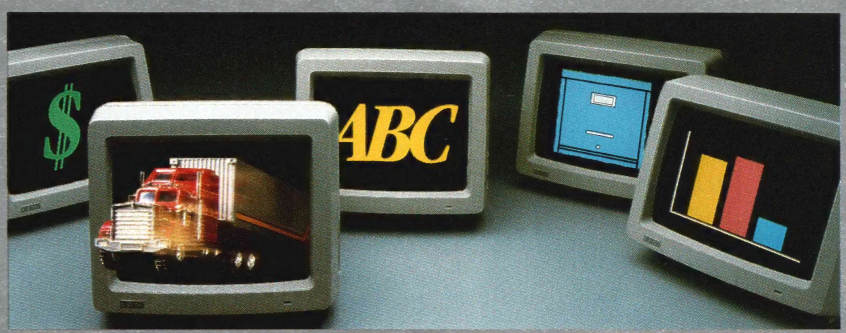

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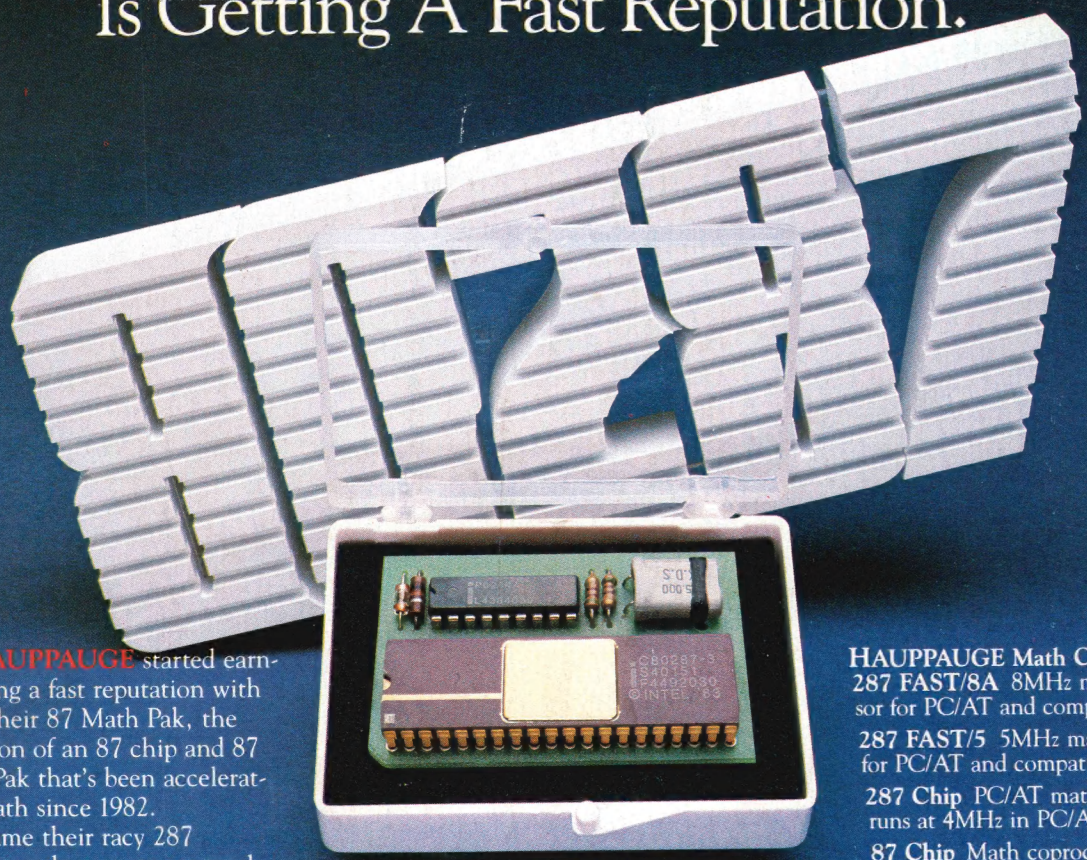

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